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The impact of product newness on new product development processes: An exploration into the information and communications technology products

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THE IMPACT OF PRODUCT NEWNESS ON NEW PRODUCT DEVELOPMENT PROCESSES: AN EXPLORATION INTO THE INFORMATION AND COMMUNICATIONS TECHNOLOGY PRODUCTS

submitted by JIN ZHONGQI

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SUMMARY

This study explored the potential relationships between product newness and new product development processes and aimed to help managers to build an awareness of product newness to improve new product development performance.

In this study, product newness was identified from three perspectives: product newness to company, product newness to market, and product newness to technology. The concept of the new product development process was abstracted as a layered model in which five attributes were of specific concern: the linearity, the parallel level, the formality, the role flexibility of marketing and the role flexibility of R&D. A set of hypotheses was then formulated regarding the relationships between the three perspectives of product newness and the five attributes of new product development processes.

The sample of this study was drawn from the British Information and Communications Technology industry via a stratified random sampling procedure. Having refined the sampling frame by conducting the telephone survey work, the data was collected via a postal survey. Using data relating to 171 products, the set of hypotheses was tested and explored further via multiple regression techniques. The research findings were validated through face to face post-survey interviews.

It was found that product newness did have an impact on new product development processes and the impact differed among different perspectives of product newness. Product newness to market, for example, was identified as an important indicator for learning and probing in new product development processes. The learning mechanism differed when a new to technology product was developed. The research findings suggested that it is beneficial for managers to develop an awareness of product newness and called for research to unpack further the learning mechanism of new product development.

CONTENTS

Appendix

Chapter 1. Introduction

Numerous new products are developed each year and for most organisations new products are the lifeblood of survival and success. What constitutes a "new" or "innovative" product can vary quite considerably. Some new products are so 'new' to the world, their emergence in the market may bring radical changes to consumption patterns or even create a new industry (e.g. the first television, personal computer, internet). While some other new products are merely modifications of existing products (e.g. adding a new feature like stereo sound or NICAM to a colour television, extending RAM capacity of a personal computer, updating an Internet browser). "Newness" of most new products, however, varies between the two extremes. This study is going to examine differences in the process of developing these different kinds of new products in the context of the British Information and Communications Technology (ICT) industry. In other words, the purpose of the study is to explore the relationship between product newness and new product development (NPD) processes and to help managers to build an awareness of product newness to improve NPD performance.

This study will focus upon information and communications technology products for the following reasons: First, a lot of research suggests that NPD processes are influenced by environmental factors such as industrial characteristics. Different patterns of NPD across industries have been identified. NPD managers in a high tech sector like ICT will not be convinced, for example, by research evidence derived from food industry. Limiting the range of research within one industry is certainly helpful to reduce the influence of these environmental factors. Therefore a number of authors called for research of innovation within one industry (Cooper and Kleischmidt 1993b, Barczak 1994).

Secondly, even if the context of this study is limited to the information and communications industry, types of products vary sharply, ranging from hardware, software, to network products that combines hardware and software together. These differences within the ICT industry sectors will be considered in this research. Hence it is easy to extend the design of this research to the case of cross industries.

Thirdly, information and communications technology industry is fast growing and technologically intensive. The fast growing and technological-intensive nature of the industry means more innovations and therefore the degree of "newness" of the product varies, which is essential for the purpose of this research.

Last but not least, according to Micossi (1996), Director General Industry of the European Commission, *"The demand and supply of information and communications technology will be the key competitive vectors of the 21st century. It is these industries and services that hold the strategic and economic keys to our future prosperity"*. UK's ICT sector has been European's market driver in recent years (Eurobit 1996), which provided a good basis for research into NPD.

There are two concepts which constitute fundamental elements of this thesis: new product development processes and product newness. Research into the newness of a new product may be traced back to Johnson and Jones (1957). But it is only recently that the problem about how newness of products relates to product development performance has received more attention. It has been contended that "newness" of products was associated with success of NPD (Kleinschmidt and Cooper 1991). They found out that "innovativeness" is both a facilitator and a detractor. That is, highly innovative products and low innovative products share a high success rate, but moderately innovative products have a relatively low success rate. They concluded that much attention should be paid to the development of "moderately new" products. The implicit implication is that different "new" products need different treatments during the development processes. Further work suggested that different "newness" in products may require different organisation structures (Olson, Walker and Ruekert 1995), which, in part, confirmed Shrivastava and Souder's contingency model (1987) which emphasises the role of contextual variables during product development and of the innovativeness of products. According to the model, different approaches should be adapted under different circumstances and for different product newness. That is, NPD is highly situational (Thomas,1995). Most recently, Lynn, Morone and Paulson (1996) argued that the existing theory of new product development was orientated mainly towards "modifications" of existing products and was no longer suitable for developing what they called discontinuous innovations (highly "new" products).

Although the attention to product newness is growing, there is a paucity of empirical evidence to show the impacts of product newness upon NPD processes. On the other side, however, there is a general trend in searching for the best model or "silver bullet" for a NPD process that provides the ultimate competitive advantage (Dwyer and Mellor 1991). Most of the models describing such a NPD process do not consider factors such as environmental or product characteristics. Typical representatives of such a search are Cooper's Third-generation model (1994) and Rothwell's fifth generation innovation process (1994). Although flexibility was addressed, product innovativeness was not considered explicitly in these models. Product innovativeness was identified as having no significant impact on product performance in a study conducted by Clark and Fujimoto(1991). They provided a best model for the NPD process of the automobile industry regardless of the nature of product newness. It was concluded that the closer a product development was to the model the better the performance.

Given the contrary features in the literature, it is therefore worthwhile to ask the question whether any relationship exists between the degree of newness of products and different patterns of NPD processes. In other words, should different NPD processes be employed for different types of products according to their newness? If so, in what way should the processes differ?

This thesis is composed of eight chapters. This chapter provides a brief description of the research topic and considerations in choosing such a topic. The purpose of Chapter 2 is to identify and evaluate various perspectives on new product development processes presented by different researchers. Chapter 2 will provide a detailed breakdown of new product development processes and will lead to a generic view of what a new product development process is. It will serve as a starting point for further exploration of the relationship between new product development processes and product newness.

Whereas Chapter 2 set a generic view on NPD processes, Chapter 3 explores the potential impacts of product newness upon NPD processes revealed in the literature. First the concept of product newness is clarified. Secondly, to get a broader picture of product newness and NPD processes, the influence of relevant environmental factors on both product newness and NPD processes is reviewed. Thirdly, some empirical evidence on the existence of the impact of product newness on NPD processes is evaluated. And finally, a set of testable hypotheses will be stated.

The purpose of Chapter 4 is to address methodological issues in examining these hypotheses in the context of the British Information and Communications Technology Industry and to describe methods used in the primary data collection. It is the intention of this chapter to make the research procedure of this study as transparent as possible and at the same time without adding too many trivial details. The first section of Chapter 4 will present an overview of the research procedure and will highlight key considerations in the research design. Section 4.2 will present measurement issues of each individual construct. The rationale for using these constructs will be briefly discussed. An issue closely related to the measurement of constructs is the development and design of a good questionnaire. This process took an unexpectedly long time in this research and Section 4.3 will describe the effort that was put into developing it. Another key issue is the representativeness of the sample. The difficulty arose in that there is little information about the population which is growing and changing from time to time. Section 4.4 will describe how a stratified sampling procedure was used and why the optimal allocation method was chosen. The whole survey design process followed the theory of Dillman's (1978) total design method (TDM). Although postal survey is the focus of this research, telephone support before and during the postal survey was provided. The research findings were validated through face to face interviews. These characteristics made this survey adopt a slightly different approach from Dillman's exact TDM procedure. Section 4.5 will highlight these considerations and will describe the unique procedure carried out in this survey. Finally, after-survey interviews presented an opportunity for discussing the findings with managers. Section 4.6 will describe a semi-structured evolutionary interview procedure used in this research.

Chapter 5 will provide a data validating process prior to the data analysis. It serves two purposes. The first purpose of Chapter 5 is to examine the responses and non-responses. Although there is no research which can claim a total absence of bias, it is important to know if the sample is useful and to what extent it is representative. In this study, the survey procedure was divided into two stages: telephone survey and postal survey. The telephone survey work served as a means of motivating the right people to participate in the survey and also a means of reconstructing and refining the sample frame so that it can reflect the population more accurately. The postal survey was the main process of collecting the survey data. For the convenience of description, the analysis will be divided into two parts analysing the characteristics of those who did not reply in the telephone survey work and those who did not reply in the postal survey. The other purpose of Chapter 5 is to examine the consistency of the measurement scales using the data collected. As the in-consistency of multiple items in measuring the same construct will make the research finding not interpretable, the importance of using proper measurement procedures cannot be underestimated.

The purpose of Chapter 6 is to provide results of the survey data analyses, which can be described from two perspectives. The first perspective is the examination of the hypotheses. Where appropriate, further data explorations were undertaken and these constituted the second perspective of the analyses. Given that the survey provided data going beyond what needed to test the hypotheses, the purpose of taking the second perspective was to detect any further findings that might emerge from the dataset.

Chapter 6 starts with an overview of the data analysis method. For the convenience of the reader, hypotheses scattered in Chapter 3 will be put together. Without too much description, a general procedure of data analyses will be described in the overview section. It will then go on to examine the hypotheses in turn. For the convenience of description, the exploratory analysis will not be separated from the hypothesis testing. To avoid tedious presentation of statistical figures, the detailed data analysis procedure will be put into appendices.

Whereas the survey data was analysed in Chapter 6, Chapter 7 explains and discusses the results of data analyses. As well reflecting how the literature may explain the nature of the data analyses, face to face interviews were conducted to further explore the results. Evidence and arguments from these post survey interviews will be presented.

For the sake of consistency, the discussion of research findings in Chapter 7 will follow the same order as in Chapter 6. Chapter 7 will start with the discussion about the relationship between the linearity of NPD processes and product newness. In each section, a brief summary of the data analysis results will be given. Then rationales behind significant results as well as insignificant results will be examined. Limitations of the research findings and future research directions will also be highlighted in Chapter 7. Finally, Chapter 8 concludes the thesis via a brief summary of the research findings and further considerations for its potential for management and future research.

Chapter 2 What is A New Product Development Process

There are two concepts which constitute fundamental elements of this thesis: new product development(NPD) processes and product newness. The purpose of this chapter is to identify and evaluate various perspectives on NPD processes presented by different researchers. This chapter will provide a detailed breakdown of NPD processes and give a generic view of what a NPD process is. It will serve as a starting point for further exploration of the relationship between NPD processes and product newness.

The chapter will start with a discussion of the concept of NPD processes. It will then apply Van De Ven's classification framework. That yields three distinctive understandings of a NPD process: 1) NPD process as an explanation of why new products succeed or fail; 2) NPD process as an underlying pattern of cognitive transition; 3) NPD process as measured attributes of certain variables. These views on NPD processes will be discussed in turn and be encapsulated into a layered model. The chapter ends with a presentation of a generic model, a simplified version of which will be used to develop ideas later in the thesis.

2.1 THE CONCEPT OF NPD PROCESSES

Although the term "new product development process" was widely accepted and used, no formal definition of the term was found. Many authors emphasised the need to better understand the process (Gupta and Wilemon 1990, Purser et al 1992). *"There is probably a great performance potential to be exploited if only the process could be properly analysed and understood (Lundqvist 1994)"*. Cooper (1986) used the metaphor of "game play" (highly risky, winning in a managed way) to address the high risk and high outcome nature of the NPD process. Takeuchi and Noneka (1986) compared the new product process to a rugby game to emphasis team spirit, co-operation and competition. Crawford (1994) used the metaphor of carpenter and toolbox to highlight the situational nature of NPD and sophisticated skills required to master the NPD process. The NPD process described in the context of Crawford, *"is a process that covers all types of situations in the most desirable way. Any manager using this generic system must cut and fit it to the situation at hand."* On one hand the use of metaphors was heuristic, on the other hand, it showed the complex, flexible and uncertain feature of the NPD process. Thus the representation of NPD process became a complicated issue. Although a great deal of effort has been put on the modelling of NPD process, there was no model that was comprehensive and integrated to describe the process (Biemans, 1992).

This research is not intended to give a formal definition of a NPD process, nor is it intended to classify all research in the NPD area. Because it is intended to explore the impact of product newness on NPD processes, it is essential to have a closer look at NPD processes first and try to unpack the "black box" of NPD processes. As it will be shown later, the extensive research into NPD in past decades has made this attempt feasible. Before going further to investigate NPD processes, an examination of the key term "process" might be helpful. According to Webster's dictionary (1996 version), a process is "a course or method of operations in the production of something" or "a forwarded movement; progressive or continuous proceeding; passage; advance; course". A NPD process, naturally, can be regarded as a course or method of operation by which a new product is developed (Craig and Hart 1992). The other meaning of process, "a forward movement, progressive or continuous proceeding", when used in the context of NPD processes, reflects the evolution and dynamic nature of new product development(Abernathy and Utterback 1975). It is the combination of these two meanings that makes the usage of the term "NPD process" confused and rather complicated. *"It is often difficult to observe the 'new product development' forest amid myriad 'results' trees (Brown and Eisenhardt 1995)".*

Similarly, Van De Ven (1992) emphasised the necessity of clarification in strategy process research:

> *"Implicitly, scholars tend to adopt very different views of strategy process, and the views they adopt influence the questions they ask, the research methods they employ, and the contributions they make. It is useful to make these different views explicit".*

According to Van De Ven (1992), there are three frequent usages of process (in broader term) in the literature:

1. Process as explanation for variance theory: a logic that explains a causal relationship between independent and dependent variables. That is, a process story or logic is used to explain why independent (input) variables exert a causal influence on a dependent (outcome) variable. It treats process here as a "black box" or "grey box". The usage is largely around the input-process-output model. In new product development literature, the widely researched outcome variable is certainly the success and failure of NPD. Explaining what the determinants of a successful NPD process are seems to be an everlasting topic.

2. Process as developmental events: a sequence of events or activities that describes how things change over time or that represents an underlying pattern of cognitive transitions by an entity in dealing with an issue. The central focus of the development process model is on progressions (i. e. the nature, sequence, and order) of activities or events that an organizational entity undergoes as it changes over time. That is, this

usage describes how a process moves forward, progresses and continuously proceeds and unfolds in a systematic way. Clearly, the usage of the term "process" as developmental events goes beyond the usage of "process" as an explanation for variance theory in that there is an effort of opening or exposing the 'black box' of the process.

3. Process as a category of concepts: instead of describing complicated causal relationships or modelling patterns of related events, process concepts are operationalized as constructs, and measured as fixed entities (variables), the measurement focusing on attributes which can vary along numerical scales from low to high, such as communication frequency, workflow, and the role of marketing, etc. One difference of this usage from the other two is that the focus is more specific, emphasising well-constructed concepts of processes.

Following this classification, this chapter will view research into NPD processes in three strands:

A. NPD process, being a course or methods to produce something new, as explanation of why new product development would be a success or failure. Instead of treating process as a complete 'black box', as Van De Ven (1992) described in the general strategic process, research into NPD stressed the course or methods perspective of processes (Craig and Hart, 1992). For example, a problem solving method, or a cross-functional team as a means of achieving better NPD was often described in the literature. But in this approach, there was no intention to treat the whole process systematically except in extracting major factors or methods which were recognised as determinants of NPD performance, either success or failure. Intuitively, this approach treated NPD process as a "grey box", that is, the information regarding how the process was being carried out was incomplete.

B. NPD process as an underlying pattern of cognitive transition beyond the explanation of success and failure NPD stories. For example, Cooper's (1986) stage-gate model which unfolded the NPD systematically via a series of decision activities aimed at achieving better NPD performance. By doing so, this approach stressed what a NPD process should be instead of what the NPD process actually was (Bessant and Francis, 1996). Because of the complexity of real NPD process, the NPD process described in this approach was usually a much simplified idealistic abstraction of the reality.

C. NPD process as measured attributes of certain variables based on established models. For example, product development as a communication web (Brown & Eisenhardt 1995), which narrowly focused on one independent variable---communication.

Whereas strand A viewed the NPD process as a 'grey box' of determinants-process-outcome, strand B unfolded this 'grey' box completely by observing it 'ideally' or in a 'stereotypic' way, which provided a resource of 'formal process', an abstraction of reality. It was on the basis of the above two approaches that strand C penetrated NPD processes on more specific perspectives. It has to be pointed out that although these three strands of views about NPD processes represent distinctly different usages of NPD processes, they are not mutually exclusive. In fact, overlaps exist between three approaches. It can been seen later that it was the research in strand A which laid the foundation for views on strand B, while research in strand B provided a test bed for the more specific concept approaches of strand C. In the forthcoming sections, these three strands of research will be reviewed in turn. Section 2.2 will examine views on strand A first.

2.2 NPD PROCESS, BEING A COURSE OR METHODS TO PRODUCE SOMETHING NEW, AS AN EXPLANATION OF SUCCESS AND FAILURE

In this section, views on what drives the NPD process to a better performance will be reviewed. This leads to summaries of how a NPD process was perceived in this strand of research.

Over past four decades, extreme efforts have been put into exploring how to develop new products successfully and why some firms failed to do so. Numerous factors in and out of the NPD process have been identified. Key players, activities, and methods have been analysed. Best practices have been promoted. This is a subject well documented by many authors and now even statistical meta-analysis is available(Montoya-Weiss and Calantone 1994). Extensive reviews on the subject can be found in (Rothwell 1977, Johne and Snelson 1988, Lilien & Yoon 1989, Craig and Hart 1992, Brown and Eisenhardt 1995) . In spite of the wide range of attention to the subject in literature, no studies in this area are considered comprehensive and further research is still needed (Brown and Eisenhardt 1995). For example, the only dependent variable in this strand of research is perhaps the success/failure of the new product. Generally speaking, the success or failure of a new product is judged on the basis whether the product's performance has reached the objective set by the firm before the new product development. These objectives can be financial (ROI, profits, sales, market share), operational (speed, productivity), strategic (competitive advantage over rivals, new opportunities, experience in a new market), etc. Given the effort made in this strand of research, it seems easy to have a clear understanding of what is success and failure for a new product. However, more than 75 distinctive measures of success have been used by firms and academics so far with little or no consensus across either group(Griffin & Page, 1996). It is beyond the scope of this research to have an extensive review on the issue and the theme is confined on the 'process' perspective, although the issue of performance measurements will be discussed further in Chapter 4.

This section starts with the first substantial study in the field. Because case studies emerged first in this strand of research and empirical studies based on large sample surveys appeared at later stage, the review will be divided into two sub-sections accordingly.

2.2.1 Case studies

The earliest work may be traced back to Carter & Williams (1957). In an extensive study of fifty firms, they examined a group of highly "progressive" firms and drew up a long list of the factors that seemed to be of some importance in successful NPD. A significant discovery they made was that 24 characteristics were related to technically progressive firms. These characteristics were also proved to be absent in "unprogressive" firms. Although it was criticised later by others (Zirger and Maidique 1990) for lack of large systematic sample study, Carter & William's research really heralded the beginning of work in this area. Many factors they addressed occurred repeatedly in later studies. As well as the classification which can be found in Barclay's review (1992a), these 24 characteristics of technically progressive firms can be summarised into five distinctive components:

(1) Positive attitude to productive innovation: openness to new ideas and effective communication.

(2) Effective personnel management: recruitment of talented people and effective training of staff; high quality in chief executives and adequate provision for intermediate managers; an ability to bring the best out of managers; use of scientists and technologists on the Board of Directors.

(3) The importance of intermediate management and uses of management techniques.

(4) Vigorous marketing: an effective selling policy, good technical service to customers; a high rate of expansion.

(5) Financial assessment: a consciousness of costs and profits in the R&D department; measurement of the outcome of investment decisions; ingenuity in getting raw materials and equipment shortages.

As for the nature of new product development, they suggested that "*progressiveness in science and technology is not an optional extra that a firm can add to its existing qualities, but an expression of its general attitude and efficiency of management*". Thus successful NPD was realised through the right people, positive attitudes, efficient use of management methods, and consciousness in evaluation. Although it was not perhaps the sole purpose of Carter and Williams' research to disclose what a NPD process was, their research did open the "black box" of new product development. The central feature of this theme was not only to explain why the determinants-process-success/failure worked, but also to pick out and to analyse factors inside the process. Subsequent research followed the same route which aimed to rationalise and streamline new product development.

Myres and Marquis (1969) studied 567 different new products developed by 121 firms. Although their findings were largely descriptive, this study was regarded as the landmark of case studies in identifying success and failure of new product development (Zirger & Maidique 1990). Two important factors they discovered as being critical to a new product were satisfaction of user needs and internal and external organisational communication. Their findings addressed the need for strong interfaces between the functional groups, particularly between R&D and marketing. As to the difference between innovations, they suggested that incremental innovations can be programmed or planned for in some way, whereas major innovations were generally unpredictable and almost accidental in nature.

Two kinds of individuals' roles were stressed in Langrish et al's study (1972). They concluded that " *innovation is a complex process involving the interaction of many factors* *(p75)".* The list of factors which they considered to be critical to the success of new product development were as follows:

- Top person: the presence of an outstanding person in a position of authority, e.g. a manager/ managing director/ technical director. The top person identified new areas to work or acted as a champion promoting interests for the project and persons working for the project.
- Other person: the mechanical genius, the person who possessed some unique area of knowledge.
- Need: clear identification of a need.
- Usefulness: the realisation of the potential usefulness as a discovery.
- Good inter- and intra-firm co-operation.
- Resources: availability of resources.
- Help: from governmental sources.

Some of the factors were considered very important by later empirical studies (Rothwell, 1974,1977). For example, the role of key individuals, user needs, and good co-operation are all considered as having strong associations with success.

It is helpful to note Globe, Levy and Schwartz's work (1973). They examined the decisive events in 10 outstanding innovations. Of the 21 factors they considered important to innovations, *"no factor was judged important for every event, and yet each of the factors was of some importance to more than one event"(p 12).* A rank order of factors was produced. The first five factors were:

. Recognition of technical opportunity: motivation for the timely improvement of an existing product or process.

. Recognition of need: motivation for solving the problem or meeting the need satisfied by the eventual innovation.

. Internal R&D management: role of supervisors and other management personnel within the performing organisation.

. Management venture decision: an organisation's decision to invest in some large scale technical activity.

. Availability of funding: the existence of financial support.

It is not difficult to see the consistency among Globe et al's work and Carter & Williams's and Languish et al's. The distinguishing feature in Globe et al's work is that they stressed the importance of funding and of the confluence of technology. Further to Myers and Marquis, they concluded that innovation cannot be fully planned. Management, in trying to promote innovation, should *"permit and encourage the opportunity to act upon ideas that fall outside the established or recognised pattern"(p15),* although they recognised that in the confluence of technology there may be *"an opportunity for management by promoting interdisciplinary R&D teams, to accelerate the innovative process."*

Other distinguished works were the series of studies organised by the Conference Board. The earlier work in this series was carried out by Cochran & Thompson (1964) and Hopkins & Bailey (1971). Later studies included Hopkins (1981). Barclay (1992) contended that sixteen years' of study had not seen significant changes in understanding how new product development processes were carried out. Of the 146 firms examined, Hopkins (1981) concluded that the first three factors leading to the failure of product development were:

. Poor marketing research: insufficient or faulty marketing research.

. Technical problems in design or production

. Inadequate timing: moving a new product too fast or too slow to market

In contrast to Globe et al and Myers & Marquis, Hopkins (1981) observed two changes in organisation and procedures. The first change was that a number of managers had strengthened new product assignments or had established full time positions in this area for the first time. Another trend was the normalisation of arrangements for ensuring closer co-operation between marketing, R&D, and other functions concerned with NPD.

Studies of Japanese product development practices in the mid-1980s provided a closer look at NPD processes (Imai et al 1985). This drew heavily from examples of the automobile industry (Clark and Fujimoto 1991, Womack and Jones, and Roos 1990). The concept of lean product development was coined and relevant techniques have been widely promoted since then (Karlsson and Ahlstrom 1996). It addressed cross-functional teams with the "heavyweight" or the "autonomous" structure, supplier involvement from the beginning of a NPD project, simultaneous engineering in which different activities in the development effort are performed in parallel. Successful product development is seen as a *"balancing act between relatively autonomous problem solving by the project teams and the discipline of a heavy weight leader , strong top management and an overarching product vision (Brown and Eisenhardt 1995)".*

One important branch of research (often neglected in the review of success and failure literature) was the use of case stories of successful and unsuccessful NPD, in which the NPD process story was used to explain why a factor was important in influencing the outcome of NPD. The NPD process story teller chose events or characteristics they thought important in describing the NPD process. These stories themselves were actually valuable data to be carefully examined. Although each case story gave useful insight on one particular perspective of NPD in a particular circumstance, it would be expected that there was a way to synthesise these research results, so that a more general view toward NPD can be obtained. The empirical research in this area certainly provided an answer.

2.2.2 Empirical studies

Rothwell et al's study(1972, 1974) was considered the first empirical study in this field. As a result of the project SAPPHO(the Scientific Activity Predictor from Patterns of Heuristic Origins), five key factors were identified to be critical to the success of new product development.

(1) Understanding user needs.

(2) Attention to marketing and publicity.

(3) Efficiency of development.

(4) Effective use of outside technology and external scientific communication.

(5) Seniority and authority of the manager's responsible for the development of the product.

The study confirmed earlier work of Carter & Williams (1956) and Languish et al (1972). Apart from the emphasis on user needs, organisational communication and authority of key individuals, the roles of development and marketing were stressed. A later study carried out by Rothwell et al (1977) emphasised further the importance of management that included careful planning and organising innovation as a corporate wide task. This stance was in contrast to the claim made by Globe, Levy and Schwartz (1973). Following the project SAPPHO, a lot of work boomed in this area with focus on different geographical locations and on different industries. For example, Szakasits's investigation into Hungarian electronic products (1974), Gerstenfeld (1976) in West Germany, Rubenstein et al's (1976) study of US firms (See Montoya-Weiss and Canltone (1994) for an extensive list).

Among this literature, the creative work of Cooper (1979) and Cooper & Kleinschmidt (1987) has to be mentioned. Cooper's project NewProd investigated 103 firms and 206 new products among which 113 were recognised successful products and 93 failed. In this research, Cooper proposed a testing methodology and a model called NewProd. The result showed that 11 out of 77 variables were most important. Among the 11 factors, 3 of which were considered to be success factors. They were:

(1) Introducing a unique and superior product.

(2) Marketing knowledge and marketing efficiency.

(3) Technical/production synergy and proficiency.

This research confirmed the common knowledge that a highly competitive product was a guarantee of success. The risk firms may run during the development of new products was also indicated in the study. Three factors were considered barriers to success:

(4) High priced product relative to competition.

(5) Being in a dynamic market.

(6) Entering a highly competitive market.

In summary, better quality, lower price and efficient marketing were proved to be strongly related to the success of product. The more competitive the market was, the harder for the success of new products. Apart from the success factors and success barriers, three "facilitators" were considered critical to new product success:

(7) A good 'product/company fit' with respect to managerial and marketing resources.

(8) Strong marketing communication & launch effort.

(9) Being in a large, growing, high need market.

Two other factors were considered weakly related to the success of new product

(10) Avoiding products new to the firms.

(11) Having a market derived idea with considerable investment involved.

The distinguishing feature of the result was the strong emphasis on highly competitive products, suitable market environment and fitness between products and firms. It was surprising that the roles of key individuals in the new product development were not explicitly identified in

Cooper's work, which were confirmed repeatedly by many other researches as described above. Following Cooper, there were a lot of similar research projects that adopted the same methodology. A recent example was by Parry and Song (1994).

Finally, it is worth mentioning an interesting work by Montoya-Weiss and Calantone (1994). They analysed 47 empirical studies of past research on the determinants of new product performance and confirmed Cooper and Kleinschmidt's (1987) speculation that much of the research to date was exploratory in nature, rather than explanatory (focused on testing hypotheses of effects and differences). They suggested that more studies that include multiple factors for diverse categories were needed.

In summary, this strand of research (i.e. process as an explanation for variance theory) was important to a better understanding of NPD processes in

- It led to an excellent and comprehensive overview of new product development and
- It helped to identify major players, activities, and techniques in NPD, therefore
- NPD process can be depicted as a course of events that produced something new by those players equipped with certain techniques. The successes and failure of the product depended on how well these players played. If their activities included those facilitators identified, their chances of success would be greater.

In other words, NPD process, in the view of this strand of research, is composed of three elements: players, activities, and identified factors specifying what characteristics those players should have and how those activities should be undertaken in order to facilitate the success of new products.

2.3 NPD PROCESS AS AN UNDERLYING PATTERN OF COGNITIVE TRANSITION

If the first strand of research reviewed above opened the "black box" of NPD, this strand of research unfolded NPD along a time dimension both normatively and descriptively (Cooper, 1983b). There has been a growing interest in the modelling of the decision making procedures of NPD. A model is, as defined by Hisrich and Peter (1984), *"basically a representation or abstraction of a real-world system and is usually a logical representation of a problem (p169)".* Most of the models about the NPD procedure in NPD literature were symbolic or more precisely, verbal models. Reviews of NPD models can be found in Saren (1984), Cooper (1994), and Rothwell (1994). In his much-cited article, Saren (1984) categorised new product development models into five types,

(1) Departmental-stage models,

(2) Activity-stage models,

(3) Decision-stage models,

(4) Conversion process models,

(5) Response models.

While Saren's typology is sufficiently comprehensive to encapsulate most NPD process variants that have been proposed since its publication in 1984, a variety of other developments in NPD processes have been proposed in the last decade such as Cooper's metaphor of three generations of NPD (Cooper, 1994), Rothwell's five generations of innovation process based on chronological order and Shrivastava and Souder's (1987) contingency model. Hart and Baker (1994) suggested that one strand of research Saren's taxonomy did not cover was that of managing NPD in networks, which de-emphasized the manufacturer-active paradigm. Based on the implications that the success literature may hold for process models and the network analysis of NPD, Hart and Baker (1994) proposed a new model which they believed was beyond the scope of Saren's taxonomy. To include these new developments in this review and to highlight common features and varieties embodied in the presentation of NPD, these models are divided into two categories: linear models and nonlinear models. In a linear model there is no cycling of process steps although the overlapping of steps is allowed. Non-linear models are those models that can not be classified as linear. These models will be described as follows.

2.3.1 Linear Process

2.3.1.1 Exact sequential models

The procedure is divided into several steps. Activities of each step are described by written language and the beginning of the later step must be preceded by the end of former step. This kind of model is called the exact-sequential model. Exact-sequential models are distinguished from general-sequential models where overlap of activities between different steps are allowed. NASA's phased project planning or the phased review process was reviewed as the first generation of new product process (Cooper 1994), which was a representation of the earliest exact sequential models. Using this technique, technical risks were reduced and the completion of tasks was ensured.

A better generalisation was developed in the early 1980s and represented by authors like Booz *et al*, Robert Cooper, Kotler, etc. Kotler (1986) described an eight step model in NPD, Booz *et al* (1982) proposed a seven step model and Cooper (1983a) developed a seven stage model. For the convenience of discussion, these three models were brought together as shown in Figure 2.1.

Main steps in NPD			
I	NPD strategy	Idea generation	Idea generation
II	Idea generation	Preliminary assessment	Screening
III	Screening & evaluation	Concept	Concept development& testing
IV	Business analysis	Development	Marketing strategy
V	Development	Testing	Business analysis
VI	Testing	Trial	Product development
VII	Commercialisation	Launch	Market testing
VIII			Commercialisation
	(Booz's model 1982)	**(Cooper's model 1983)**	**(Kotler's model 1986)**

Figure 2.1 Models for NPD

A brief comparison might suggest that there were more common points than differences among the three models. All of the models stressed the importance of idea generation. As Cooper (1986) pointed out that "*a good new product idea can make or break a project*" (p49). At this stage, sources of new product ideas and some idea generating techniques were described in each model. It seems that there was not much difference in the treatment of idea generation between different models. Primary resources of idea generation were mainly internal sources (researchers, engineers, sales representative, dealers, production managers and top managers, etc.) and external sources (customers, contract research organisations and consultants, technical publications, competitor, universities, etc.). Idea generation techniques were described at this stage, such as Attribute Listing, Focus Groups, Forced Relationships, Brainstorming, Problem Inventory Analysis, Synetics and Morphological Analysis. Kotler (1988) stated that "*really good ideas are out of inspiration, perspiration and techniques (p317)*".

Most of the techniques, however, were established on basic existing products. Myres and Marquis (1969) suggested that minor (incremental) innovations can be programmed or planned for in some way, whereas major innovations were generally unpredictable and almost accidental in nature.

The stage following idea generation was the assessment or screening and evaluation of ideas. After the screening, the most promising ideas were carefully defined and developed into concepts that make up the basis of product development. One of the distinguishing features of Booz's model was that it stressed strategy which was placed at the beginning of all stages. The other two models emphasised the importance of concept development.

Most importantly, all these models implicitly stressed the transitive or evolutionary nature of new product emergence. Five forms of a new product existed during its development:

Idea form: a vague plan or belief, a proposal.

Concept form: a feasible protocol, a product in its paper form or digital form.

Prototype form: usable form of the product before it was available to its customer.

Product in trial form: small amount of the product made available for sale to its customer.

Product launched, the final form

The main concerns of these models were techniques and activities to guarantee a cost-effective transition of different product forms in the development process. Subsequent models followed the same route. They emphasised not only how product forms were transformed but also considered variants of activities and steps under different situations.

2.3.1.2 The contingency model (Shrivastava and Souder 1987)

One of the breakthroughs in the modelling of NPD was the contingency model proposed by Shrivastava and Souder (1987). The main differences between their model and the exact-sequence model were

* The uncertainty of product development was considered.
* An effort to deal with different types of products was made.
* The process did not have to be exactly sequential. There may be no clear distinction between steps and steps may overlap.
* A transfer point between following steps was added.

The transfer across stages was managed through one of the following models:

* The stage-dominant model characterised by functionally specialized formal groups with predefined specific tasks, stages described in terms of the incumbent member's responsibility and activities, formal institutionalized transfer points between stages and functional groups with extensive paper work.
* The process-dominant model characterised by informal project grouping with continually redefined functions and activities, iterated processes with no formal transfer points and no clear stages and little paper work.
* The task-dominant model characterised by a process described in terms of tasks for developing the end product with continuous over-lapping of communications channels, and no grouping of project members, no functional identity of the project team, no formal transfer points.

2.3.1.3 Stage-gate models

This was a name coined by Cooper(1986). Stage-gate models were also step by step models. They were distinguished from exact-sequential models in that

* A decision point was added between every following step.
* Parallel or concurrent processing was stressed.

* Marketing and manufacturing were integral parts of the product development process.

* The stages or gates were cross functional, i.e. no marketing-specific or manufacturing-specific stages or gates.

2.3.2 The trend toward parallel models

As reducing the development time and increasing the speed of NPD have drawn more and more attention (Nijssen, Arthur, and Harry 1995, Millson, Ray and Wilemon 1992, Crawford 1992), parallel models were proposed to replace the sequence models in the literature. Among them, Barclay (1992) suggested a parallel process model that took new product activities as interdisciplinary activities many of which could be carried out interactively. Cooper(1994) proposed his so-called third generation of new product processes, which could also be regarded as a stage-gate system by allowing possible overlapping of following stages. It was characterised by four fundamental F's:

- Fluidity: fluid and adaptable with overlapping and fluid stages for greater speed,
- Fuzzy gates: conditional GO decisions, dependent on situation,
- Focus: builds in prioritization methods, focuses resources on the best bets,
- Flexible: not a rigid stage-and-gate system; each project is unique and has its own routing through the process.

These models were also descriptive and in some sense fuzzy in definition. They may serve as a guide to NPD although it was more difficult to follow than the stage-gate model proposed earlier.

In summary, NPD process in the sequential modelling approach can be described as a transition of product forms along a time dimension. The transition pattern was described in two perspectives, one was the players and activities perspective, which drew heavily from the first strand of research, the other was the space perspective. The overlapping of activities and integration of players were stressed on the most recent models. The influence of context variables on the transition pattern was also a consideration.

2.3.3 Non-linear process

As to the linear process model of NPD, there was a clear beginning, several middle stages and a clear end of the whole development procedure. However, the NPD process was not always linear. The termination of one concept may give birth to another new concept and the NPD process was a process of iteration and feedback (Hart and Baker , 1994). Up to now, the research on the non-linear model is still continuing. Tidd (1997) contended:

> *"There is a consensus that the innovation process is non-linear, but existing models incorporating simple feedback loops are too imprecise to have much explanatory power or practical implication.(p15)"*

On the basis of network analysis, Hart and Baker (1994) proposed a conceptual framework of NPD that was a typical non-linear model and they called it the multiple convergent processing model. An example of their model was shown in Fig. 2.2.

Although much more complicated than the linear model, it can still be observed clearly that the multi-convergent process model followed the same pattern with other models as suggested in the last section. That is, the model was about how different product forms were transformed by key players (six kinds of different players were presented explicitly in the first layer of the model, see Fig. 2.2). These players were supposed to undertake certain activities and to use a number of techniques in a desired way.

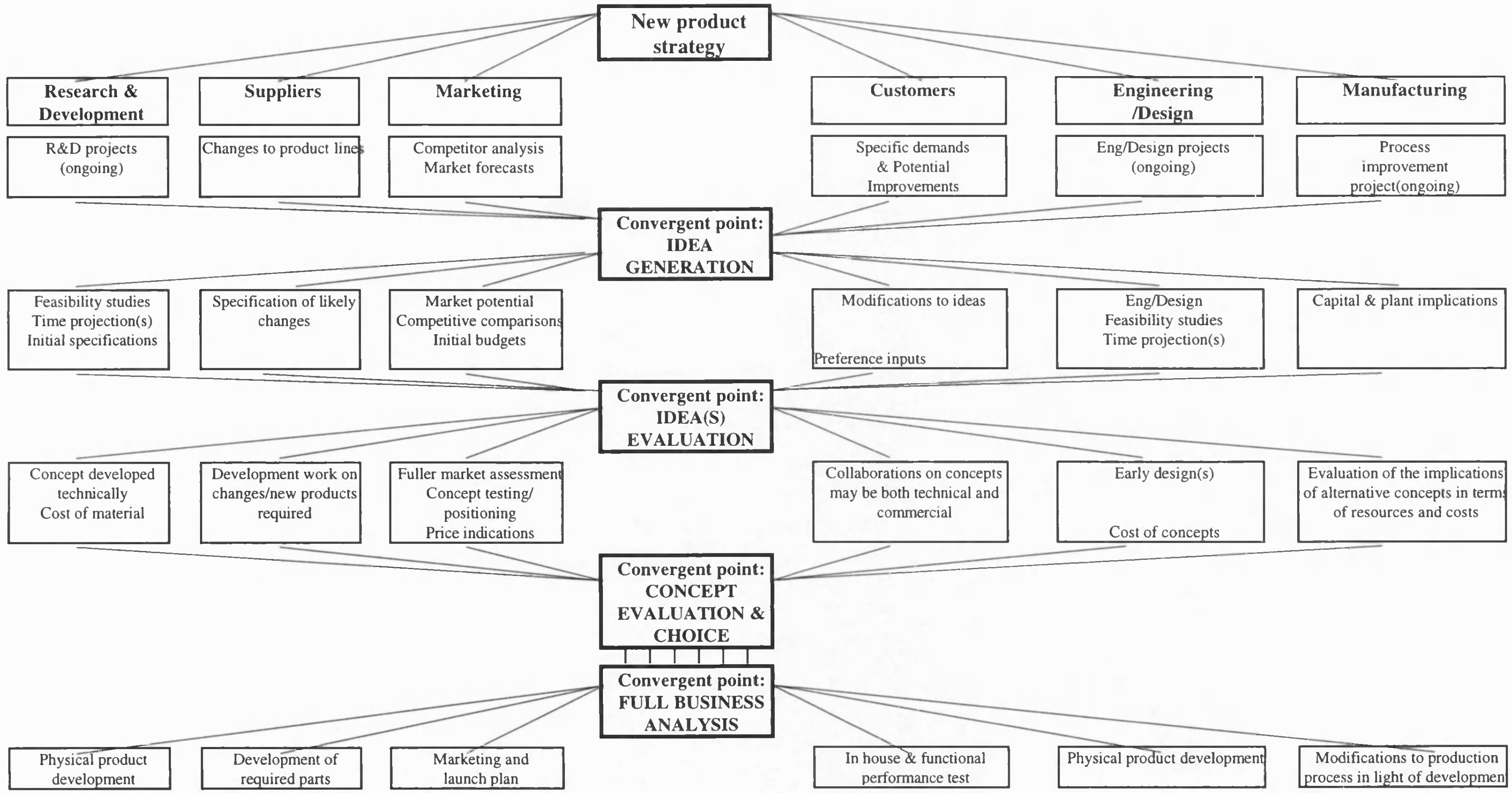


Figure 2.2. An example of the multi-convergent process model

Rothwell (1994) proposed a framework of what he called the fifth-generation innovation process[1]. It includes fully integrated parallel development; strong linkages with leading edge customers; strategic integration with primary suppliers, including co-development; strategic alliance where appropriate; emphasis on corporate flexibility and on development speed; and focus on quality and other non-price features. Twenty-four characteristics of the process were identified which related to either speed or efficiency of development. The main characteristics were:

Integration

Flexibility

Networking

Parallel (real time) information processing

He suggested that *"in the case of innovations involving the development of a major new technology it would be unwise to opt initially for a full parallel process"*. A linear process with limited functional overlap is probably the best.

In summary, the second strand of research provided a closer look at the NPD process. It unfolded NPD along a time dimension. Despite sharp differences and terms used in these models, a common theme was that new product development players organized activities around five product forms: ideas, concepts, prototypes, product in trial, and product launched. The research findings in the first strand of research were incorporated into this transition process to form the best ways of NPD. A further question might be to ask: Will these models work in real NPD? Griffin (1995) * suggested that

[1] According to Rothwell (1992), the first generation was a linear technology-push model; the second generation was a linear market-pull model; the third generation was a logically sequential process divided into a series of interdependent stages, coupling between science, technology and market place; the fourth generation was largely an integrated Japanese style approach.

* Private communication, December 1995.

" As far as type of process is concerned, again, I have found that so few firms have truly implemented QFD and other processes that the biggest impact is whether they have a formal product development process at all, rather than on the more subtle differentiation between type of process ".

Studies in Canada, Australia and UK (Cooper and Kleinschimidt 1986, Wind and Mahajan 1988, Dwyer and Meller 1991, Thwaites 1992) discovered that at least 13 activities described by these models were used by firms surveyed in these countries. But the degree of proficiency of these activities varied among different firms and projects. Most of these models just provided a "tool kit". They ignored the circumstances the NPD was involved in. That also created confusion for managers about how NPD activities should be carried out. The promoter of accelerating product development (APD), for example, can enumerate a long list of advantages of APD and successful examples of companies using APD techniques. A critical investigation, however, generated more persuasive evidence against APD (Crawford 1992). The argument was that any model should be considered in a particular circumstance. No model was effective at all circumstances. This therefore prompted the need to explore the relationship between NPD processes and their contexts (Bessant & Francis 1996, Krubasik 1988).

2.4 NPD PROCESS AS MEASURED ATTRIBUTES OF CERTAIN VARIABLES BASED ON ESTABLISHED MODELS.

Compared with the other two strands of research on NPD process, this strand of research was by no means satisfactory although this usage of the term “process” was characterised by Van de Ven (1992) as the “most frequently used meaning” in the strategy process literature. In this usage, the NPD process itself was regarded as a distinguished entity and a number of attributes were proposed. Reviewed here are five attributes proposed in the literature: role of R&D, role of marketing, formality, linearity, and degree of parallel level.

2.4.1 The role of R&D and marketing

This strand of research can be traced back to Cooper's (1983) earlier work on NPD processes. In the article, 58 new product cases in 30 industrial product firms were investigated. The new product processes were classified into seven clusters. Three common attributes were used to compare and clarify these seven different approaches. They were: marketing activities, technical/production activities and evaluation activities. He concluded that a reasonable balance between market oriented and technical/production activities should be struck. No one side should dominate at the expense of the other. The role of R&D and the role of marketing as important attributes in NPD processes were further stressed in the following studies (Gupta, Ray, Wilemon 1986, Moenaert, Souder, De Meyer and Deschoolmeester 1994, Griffin and Hauser 1996).

Workman, Jr. (1993) suggested that there has been little empirical examinations of the actual role and activities of marketing groups in high-tech firms. He observed in a computer system firm:

> *"Given the over-all negative attitude toward marketing within Zytek, many tasks traditionally thought of as marketing (Such as ...) are done in the engineering groups (p412)."*

This marginal role of marketing contradicted the role prescribed in traditional marketing text books. It also highlighted the importance of this "role" changing or integration between R&D and marketing in high technology firms.

Via metaphorical reasoning (Daft,1983), Moenaert and Souder (1990) proposed the concept of 'role flexibility', which referred to the degree of extrafunctional tasks a project member assumed in the course of the project. The role flexibility of R&D was defined in Moenaert et al (1994) as the degree of marketing activities (e. g. contacting consumers) conducted by R&D personnel. Similarly the role flexibility of marketing personnel was defined as the degree of R&D activities (e.g. running lab tests) performed by marketing personnel. It was shown that role flexibility stimulated information flows between marketing and R&D personnel, but it did not always facilitate positive performance and new product success. A possible explanation from Moenaert et al (1994) was that this role of R&D and marketing, like the concept of project centralization in some circumstances facilitated NPD success, in some circumstances has a detrimental effect. That is, the role flexibility of R&D and marketing was situational.

2.4.2 Formality of NPD processes

Another important attribute of NPD process was revived from existing concepts of organizational behaviour studies (Pugh et al 1969, Kanungo 1979). According to Gupta, Ray and Wilemon (1986), formalization was the emphasis placed within the organization on following rules and procedures in performing one's job. Moenaert et al (1994) showed that project formalization correlated significantly in hypothesized direction with commercial project success. Gupta, Ray and Wilmon (1986) argued that formalization appeared to be both a facilitator as well as a barrier to the integration of R&D and marketing. One the one hand, formalization may cause estrangement or non-involvement among professionals. On the other hand, lack of formalization may result in role ambiguity (Rizzo, House, and Lirtzman 1970). To relate formalization to project performance, Olson, Walker, and Ruekert (1995) concluded that "it depends". They suggested that formalization may facilitate better NPD performance moderated by the degree of product newness.

2.4.3 Degree of parallel level

With the widespread use of concurrent engineering approach in NPD by some well-known companies like General Motor, Chrysler, Ford, Mortorola, Hewlett Packard and Intel (Clark 1989) in 1980's and early 1990's, the degree of parallel level of NPD processes or concurrency was identified as one of the key domains in recent NPD literature (Swink, Sandvig, Mabert 1996). Via their in-depth case studies, Swink, Sandvig and Mabert (1996) clarified the concept of concurrency in three layers: product concurrency, design concurrency, and project phase concurrency. In this study, the degree of parallel level of NPD process referred to what they called conventional sense concurrency: project phase concurrency. This addressed sequential stages of the product life by over-lapping designs and development activities, which involved simultaneously developing market concepts, product designs, manufacturing processes and product support structures(Swink, Sandvig, and Mabert 1996).

2.4.4 Linearity and non-linearity of NPD processes

The linearity of NPD processes as an important attribute was proposed in Jin, Birks and Targett (1996). It refers to the extent to which the process can be classified as linear, that is, a process with few activities reiterated and almost no feedback. The concept was constructed via a triangulated laddering method (Fransella and Bannister 1977) by collecting over 30 cases in the literature describing a variety of successful NPD projects ranging from Ford Mondeo , Cellular One to Body Shop and the Tractor. The non-linearity of a process was identified as an important facilitator in accelerating NPD processes. The importance of this dimension was further reflected in Lynn, Morone, and Paulson (1996). They looked at the NPD process in a broader extant. Via analysing a diverse set of successful cases, they uncovered "a process of probing and learning". Firms developed their products through successive approximations, which was an iteration and feedback procedure beyond project phase development, that is, a family of products instead of one product were developed. The development of previous products, which may not be a success at all, provided experience and opportunity for the development of later products. It was in this sense the procedure iterated. The importance of this concept was also stated in Hart and Baker (1994) as one of their main reasons to build a new NPD model---multi-convergent NPD model as reviewed in section 2.3.3. However, no operationalised multiple item measurement was found in the literature, except Eisenhardt and Tabrizi's (1995) use of 'design iterations', in which they asked respondents directly how many iterations occurred in the development process. It was found that both the degree of parallel level and the linearity of NPD processes are very complicated concepts. Their measurements should be based on a certain NPD model, otherwise there will be no criteria to evaluate it or it will be impossible to replicate the study.

In summary, by characterising a NPD process via different attributes, one should be able to relate the NPD processes to other factors to measure, if other factors changed, how the NPD process would react. Or, if the NPD process attributes differ, what would be the outcome? Unlike the first strand of research reviewed earlier, a common feature of the five attributes reviewed was that they did not present themselves as determinants of success or failure of NPD. It was strongly suggested in the literature that these attributes were highly situational regarding their relationship to NPD performance.

2.5 SYNTHESISED VIEW ON NPD: A SUMMARY

In the perspective of the first strand of research reviewed, a NPD process was composed of three elements: players, activities and related factors in and out of new product development. The second strand stressed the transition pattern of NPD process along the time dimension. Despite sharp differences and terms used in different models, a common theme was that NPD players organize activities around five product forms, ideas, concepts, prototypes, product in trial, and product launched. The third strand of research regards the process of developing a new product as an entity itself. The NPD process, in this perspective, was characterised via measured variables. To put all these together, four layers of views on a NPD process were encapsulated as follows:

Probing and Learning intensity

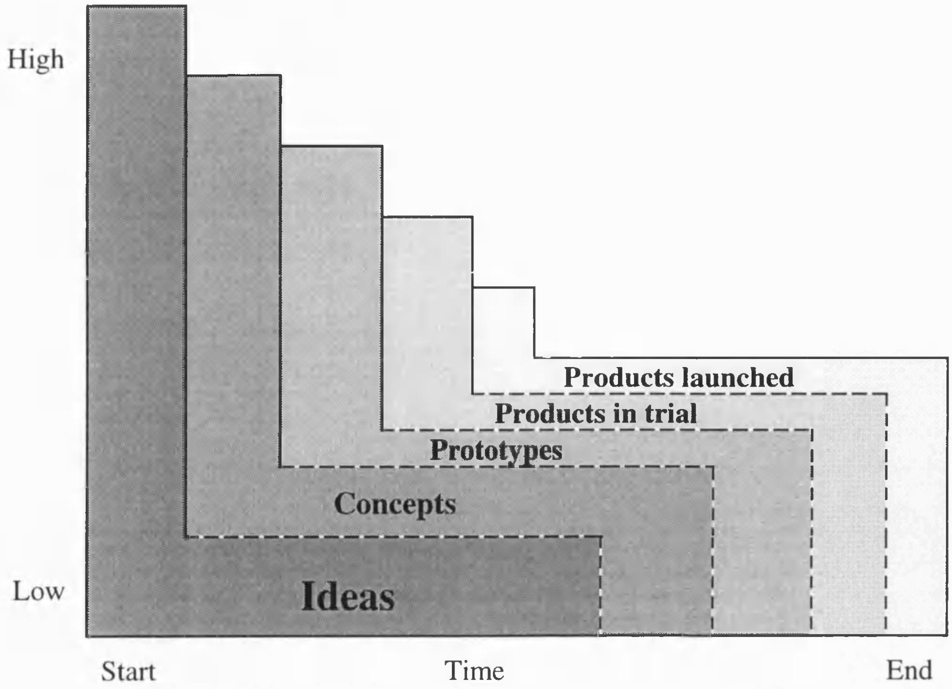


Fig. 2.3 Probing and learning layer of NPD processes

1) Probing and learning layer: Perhaps the most important view obtained from past research is that NPD process is, in the first instance, a learning and probing process. Much NPD research is concerned with the streamlining and rationalising of the NPD process to reduce the risk of this learning and probing process so that the chance of success is greater. The learning and probing nature means that a NPD process cannot be completely programmed or planned (Myres and Marquis 1969). A product may not be developed directly for launch. The process is evolutionary. The form of product appears as ideas, concepts, perhaps prototypes, products in trial, and finally the product to market. A graphic description of the probing and learning layer is shown in Fig. 2.3.

In Fig. 2.3, five different product forms are separated by five different channels. These channels reflect evolutionary processes for each of the five different product forms. The bottom channel on Fig. 2.3, for example, represents the process of generation of ideas, evaluation of ideas, and progression of ideas to concepts or other advanced product forms. The dashed line between idea channel and concept channel reflect that there are no definite boundaries between these forms. They may be interwoven during the development process. The horizontal axis reflects project development time. As time goes on, the product form is transformed from ideas to concepts, from concepts to prototypes, and finally to the launch stage. The graph shows also that different product forms may exist at the same time and there could exist overlaps, interactions and feedbacks from the advanced product form to the earlier product form. For example, an idea may be generated after a concept. The vertical axis reflects the intensity of probing and learning. That could be expressed in terms of the number of ideas generated, or uncertainty of learning to be reduced. The scale here, of course, only has symbolic meanings. It expresses a trend in general that the number of ideas generated in the NPD process, for example, is greater than the number of prototypes obtained in the process.

This learning and probing process cannot simply be compared to the concept of product life cycle. As reviewed in the second strand of NPD research, NPD processes often include overlaps and iterations. It is quite normal for an idea to be 'killed' at some stage and another idea "given birth" (generated) sometime later. It is this iterative process that makes the project move forward.

2) Entity layer: One of the major concerns in the first and the second strand of NPD literature reviewed is that of who plays in the NPD process and what they do in the process, which can be represented by a number of entities. According to Chen (1976) an entity was referred to as any distinguishable set of things or activities in the world. Here the term is used to mean any distinguishable parties or key players involved in the process such as R&D, Marketing, or customers and distinguishable activities carried out in the process such as test market, full business review.

The entity layer can be divided further into two sublayers, the first is the players layer which consists of entities which participate in NPD processes. Typical entities can be, as summarised in Brown and Eisenhardt (1995), project team, project leader, senior management, suppliers and customers. The behaviours of these players, as reviewed in the first strand of the NPD process research, were identified continuously by researchers as key facilitators or barriers for new product success. Yet no models of NPD processes placed these players in an explicit position, although their activities were constantly addressed as in the second strand of NPD process research.

The second sublayer consists of activities involved in the NPD process, such as idea generation, idea screen, formal business analysis, test marketing, etc. A lot of activities were identified in the literature. The depth and proficiency of these activities being carried out were claimed to be related to better new product performance (Cooper and Kleinschmidt 1986).

Each entity has its own attributes. Project team, for example, can be characterised by several factors which have been identified important in the literature, such as composition of the team, group process, and work organization (Brown and Eisenhardt, 1995).

3) Relationship layer: this layer refers to how different entities in the entity layer are related and how these relationships interact with each other. There are three types of possible relationships between entities:

a. Player-player relationship

A lot of research dealt with player-player relationships such as customers and project teams, R&D and marketing, etc. An extensive review of the relationship between R&D and Marketing in NPD, for example, can be found in Griffin and Hauser (1996).

b. Player-activity relationship

It might not be an exaggeration to say that most research into NPD processes can be built on certain types of player-activity relationships. From the earlier research of Carter & Williams (1956) to the very different Japanese studies in early 1990s (Clark and Fujimoto 1991), all put choosing the right people, and doing the work well as the key determinants of NPD. That is the driving force in the trend to streamlining and rationalising NPD.

c. Activity-activity relationship

Relationship between activities is implicitly expressed in most of NPD models. For example, the sequence of different activities, possible iterations, etc. By explicitly present activity to activity relationships in NPD processes, the combination of parallel and exact sequential models is made possible. The express power of the model is therefore enhanced.

4) Attribute layer: This layer directly reflects the third strand of research reviewed in section 2.4. The NPD process itself can be regarded as a distinguishable entity in the whole category of NPD of a firm or in the market. It can be characterised by many factors such as the role flexibility of marketing, the role flexibility of R&D, formality of the process, the parallel level of a NPD process, the linearity of a NPD process, performance of NPD, etc.

It is illustrated in Fig. 2.4 this layered view of NPD process and its relationship with the three strands of research.

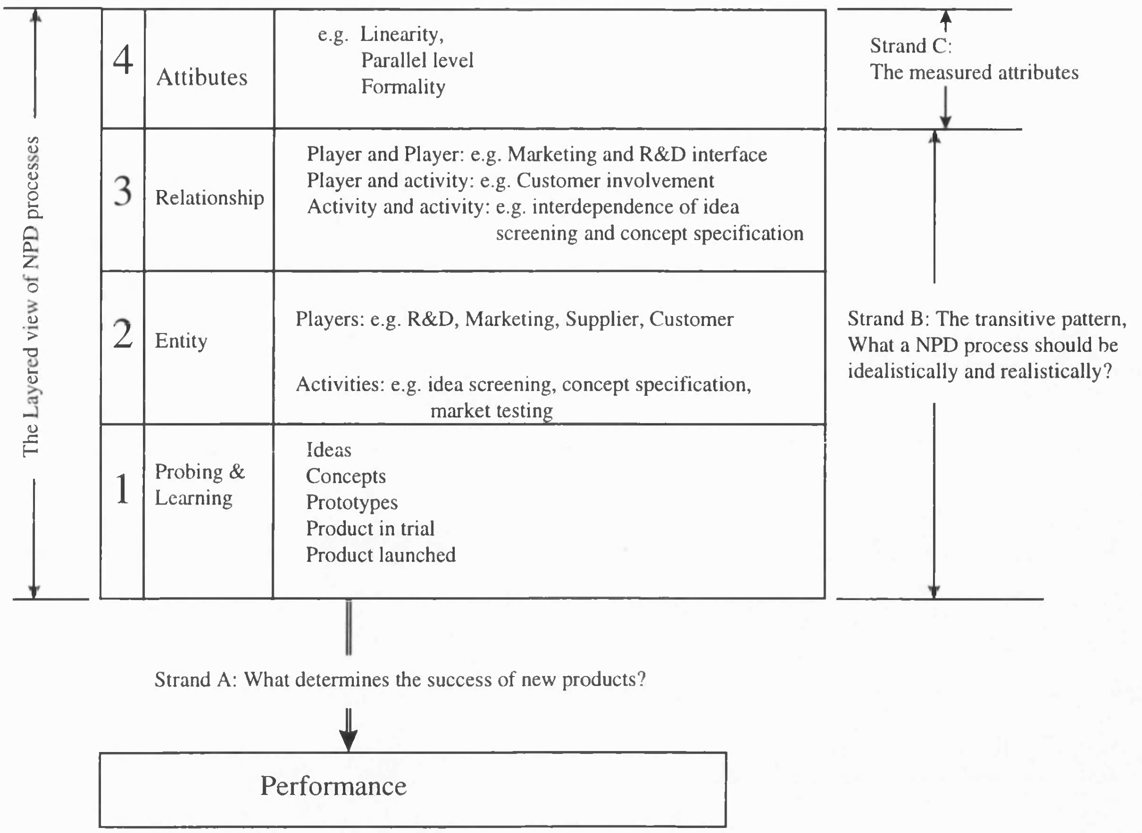


Fig. 2.4 The layered view of NPD processes and its relationship with the three strand of NPD approaches.

As it is shown in Fig. 2.4, this synthesised view on NPD process does not specify what a NPD process actually is, instead it provides a platform for further research into new product development, especially for the sake of this study. There are several advantages of using this model. First it can be used as a concept of the "tool box" as described by Crawford (1994). The model recognised the NPD process as a complicated dynamic system by setting up four different layers. The entity layer and the relationship layer reflect the idea of "tool box". It not only includes "tools" (activities), but also includes "carpenters" (players). The relationship layer explains how the "carpenters" use these "tools", how they communicate, and how these "tools" can be positioned with each other. Linking the entity layer and the relationship layer to the learning and probing layer will make the model become "dynamic" as the product emerges from ideas to its final form. It is therefore the task of the next chapter to examine how dynamic NPD processes vary when developing different types of products, given some products are new to the world and some others are merely modifications of existing products. Perhaps a more fundamental question would be: do NPD processes vary according to product newness? Based on the layered model, the relationships between NPD processes and product newness will be explored in the next chapter.

Secondly, the model recognises the importance of the NPD process as a distinguishable entity. A potential advantage is that a NPD process is regarded as a whole: a unit of analysis. This opens the possibility for more complicated network analysis and using this model it is also easy to put an individual project in a portfolio context. Thirdly, the four layers of the NPD process are not isolated. They should be linked closely. For example, the attribute layer is closely linked to the entity layer and the relationship layer. Because the attribute of a NPD process is so complicated, it will not make sense in the quantitative perspective, if it is discussed without specifying players and activities. For example, the concept of the linearity of NPD processes and the concept of the parallel level of NPD processes, by definition, refer to the degree to which iterative activities and the degree to which overlap activities are carried out in the NPD process. Without limiting the meaning of "activities", the meaning of iteration and overlapping would not be accurate.

Last but not least, this synthesised view was derived from the three strands of research reviewed early in this chapter. Reflecting back upon those views on NPD processes, this model combines the three usages of NPD processes. First the NPD process as an explanation of success can be explicitly explored within the entity layer and the relationship layer regarding product performance as a special entity. The model for integration of R&D and marketing in Gupta, Ray and Wilemon (1986)'s article, for example, fits in nicely in the layered model. Fig. 2.5 explains how Gupta, Ray, and Wilemon's model was served as a simple case of the proposed model.

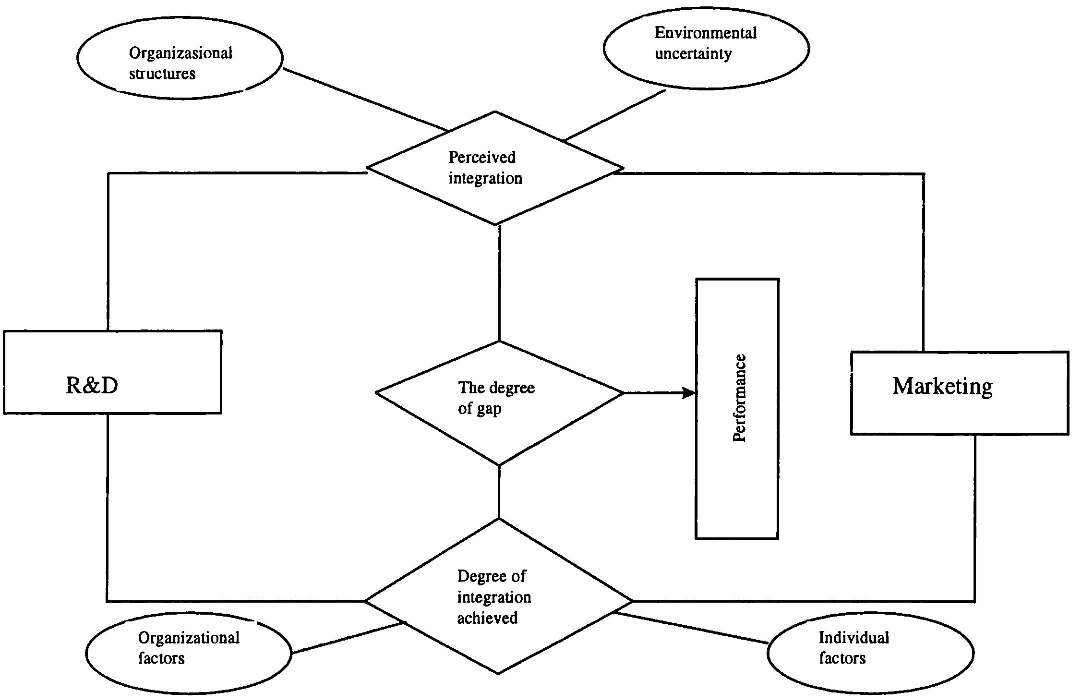


Fig. 2.5 The integration model as an example of the generic NPD model.

In Fig. 2.5, Rectangles represent entities, rhombuses expresses the relationships between two or more entities. Ellipses show the attributes of corresponding entities or relationships. It can been seen in Fig. 2.5, there are two kinds relationships between R&D and marketing: the expected integration and the actual integration. Fig. 2.5 shows that the gap between the two relationships may influence the performance of NPD.

Secondly, the proposed model has the power to encapsulate all the patterns being reviewed in the second track. The exact sequential model, for example, can be regarded as a special case of the layered model by keeping only the entity layer. In more complicated case, Hart & Baker's multiple convergent model, for example, can be represented by explicitly relating the probing and learning layer to the entity layer.

Finally, because an attribute layer of NPD process was explicitly included, the third usage of NPD process was clearly included in the model.

Having established a synthesized view on NPD processes via a layered model, it is therefore the main task of the next chapter to review the potential relationship between NPD processes and product newness.

Chapter 3 Product Newness and NPD Processes

The development of really new products has been seen as a source of sustainable growth which can provide a cutting edge for firms in competition. Lynn, Morone, and Paulson (1996) suggested: "A careful reading of recent industrial history leads to the conclusion that in competitive, technology-intensive global markets, advantage is built and renewed through the more discontinuous form of innovation---through the creation of entirely new families of products and businesses. Continuous, incremental product line extensions and improvements are essential for maintaining leadership, but only after it has first been established through the more discontinuous form of innovation (p 10)". However, past NPD approaches can be criticised as mainly concentrating on the development of "incremental products", the methodology and techniques developed hitherto are not suitable in a "discontinuous" context (Lynn, Morone, and Paulson 1996).

Whereas Chapter 2 set a generic view on NPD processes, this chapter explores the potential impact of product newness on NPD processes revealed in the literature. First the concept of product newness is clarified. Secondly, to get a broader picture of product newness and NPD processes, the influence of relevant environmental factors on both product newness and NPD processes is reviewed. Thirdly, some empirical evidence on the existence of the impact of product newness on NPD processes is evaluated. Fourthly, on the basis of the layered NPD process model being developed in the last chapter, the impact of product newness is described from three perspectives(layers): 1) The impact of product newness on the probing and learning layer 2) the impact of product newness on the entity layer 3) the impact of product newness on the attribute layer. Finally, in the last section of this chapter a conceptual framework was proposed as a summary of the literature review. The conceptual framework will be therefore examined by empirical evidence in the forthcoming chapters.

3.1 WHAT IS "NEWNESS" IN NEW PRODUCTS

The definition of "newness" of new products and the classification of new products according to newness were interwoven in literature. At the heart of the classification of new products was the definition of "newness". Baker (1979) pointed out

> "*What constitutes a new product? There can be no hard-and-fast answer, for newness is essentially a subjective concept that depends upon one's state of knowledge or, in the case of a firm, its current range of activity.*"

The subjectivity of "newness" made the classification of new products a difficult task.

A key contribution to this field was made by Booz, Allen and Hamilton(1982). Derived from Ansoff's (1957) original product/market matrix, they proposed a landmark definition of new products. To them, newness can be defined in two senses:

New to the company: the product is the first to the firm.

New to the market: the first kind of product in the market.

On the basis of this definition of newness, six different classes of new product can be identified which were shown in a two dimensional map (See left side of Fig. 3.1). The six categories were:

* *New to the world products (first of its kind and creates an entire market)*

* *New product lines (established products new to the company)*

* *Additions to existing product lines (established products new to the firm that fit into the firm's existing product lines)*

* *Improvements and revisions to existing products*

* *Repositioning (new applications for existing products i.e. existing products retargeted to a new market segment)*

** Cost reduction (new products yield similar performance and benefits to the old products but at a lower cost)*

This definition of "newness" and classification was widely accepted and repeatedly used in product development research (Cooper,1988 Coxhead and Davis 1992).

To explore it further, the classification of new products may be traced back to Robertson (1967) and Johnson and Jones (1957). On the basis of the disrupting influence the use of the product had on established consumption patterns, Robertson proposed a continuum that contains three categories:

** Continuous innovations---least disrupting influence on established consumption patterns. Alteration of a product is involved, rather than the establishment of a new product (e.g. annual automobile changes, fashion style changes).*

** Dynamically continuous innovations---some influence on consumption patterns but not enough to alter the established patterns (e.g. electric carving knife).*

** Discontinuous innovations---require new consumption patterns and the creation of previously unknown products (e.g. television, computers).*

This classification was based on a 'process' point of view, that is, innovation was a process to meet consumer needs. Robertson (1967) reckoned that much innovation was "programmed" innovation whether it was for industrial goods or consumer goods. This classification was very much like what later being used by Kleinschmidt and Cooper's study (1991). The distinctive perspective of the classification was that it linked innovation classification with established patterns, which was not reflected explicitly in Booz et al's category of new products.

Apart from Robertson's classification, Johnson and Jones's (1957) category may be regarded to be the first in this field and it is still relevant today (Hisrich and Peters 1984). To them, newness has also two dimensions: new to the market (which was reflected in Booz Allen & Hamilton 1982) and new to the technology. With these two dimensions, eight diversifications were identified. A comparison between Booz's classification and Johnson's classification is exhibited in Fig. 3.1. It is not difficult to understand the similarity between Booz's and Johnson's classifications. "New to the world products" in Booz's classification corresponds to the "diversification" in Johnson's classification. Similarly, "cost reduction" in Booz's category corresponds to "reformation " in Johnson's. And "repositioning" corresponds to "new use".

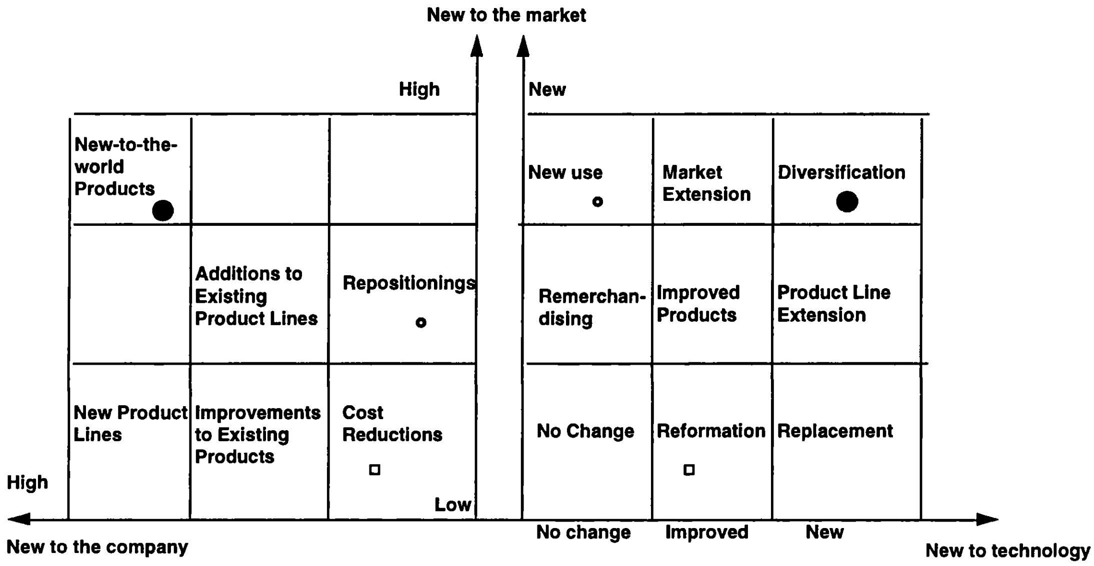


Fig. 3.1 Categories of New Products: A Comparison
(Booz Allen & Hamilton 1982 vs. Johnson and Jone's 1957)

That is, although newness is basically a subjective concept, there still existed some common points in the literature about classification of new products according to newness. Booz Allen & Hamilton's definition put emphasis on the market and the company, while Johnson's definition stressed the market and the technology. Both of them put strong emphasis on the market, but still there was some confusion in the market concept they used. In Booz Allen & Hamilton's classification, for example, they failed to distinguish the target market and the rest of the market. A product, for example, which is new to the company and to the target market, is not necessarily new to the world. And this product lies in no categories of Booz's new products. This may be called incompleteness of classification.

Another difficulty arises with Booz's definition is that the degree of newness in the same category may vary greatly, some are really new products, for example, while others may be just "small modifications". The difference of “newness” is so great in the same group of “new product line” that a re-classification is needed (Kleinschmidt and Cooper 1991). Johnson's definition ignores the existence of the individual company which may cause difficulties in the context of NPD as it has already been noticed that NPD is closely related to a firm's current range of activity (Baker, 1979). A possible alternative to the definition of "newness" is a combination of Booz, Allen and Hamilton's definition and Johnson and Jone's definition. In other words, newness in the technology perspective could be added to Booz, Allen and Hamilton's "newness" definition of new products. This is particularly important because the technology content is a very important dimension in information and communication technology products. A "pentium" chip, for example, might not be new to the market or the company, but it is new in technology.

In summary, although product newness is a subjective concept, a number of common points were shared in the literature. First, product newness is a multi-dimensional concept. It can be measured along at least in three dimensions: newness to market, newness to technology, and newness to company. Secondly, although there are various classifications of new products according to newness available, none of them include all of the three dimensions. And finally, categorical classification of new products according to newness may cause problems in that the degree of “newness” varies even in the same group.

3.2 THE INFLUENCE OF ENVIRONMENTAL FACTORS

This study concerns the impact of product newness on NPD processes in the UK's ICT industry. However, the development of a new product in a firm is not isolated. Normann (1971) suggested: " *that innovation is a very complex process which should be considered in the large context of the organisation-environment relationship*". Although it is intended to limit the attempt within one industry in one country, the influence of the environment on NPD processes should not be ignored. This is illustrated in Fig. 3.2.

As it is shown in Fig. 3.2, to get a broader picture of product newness and NPD processes, the influence of relevant environmental factors on both product newness and NPD processes will be explored before going further to examine the impact of product newness on NPD processes.

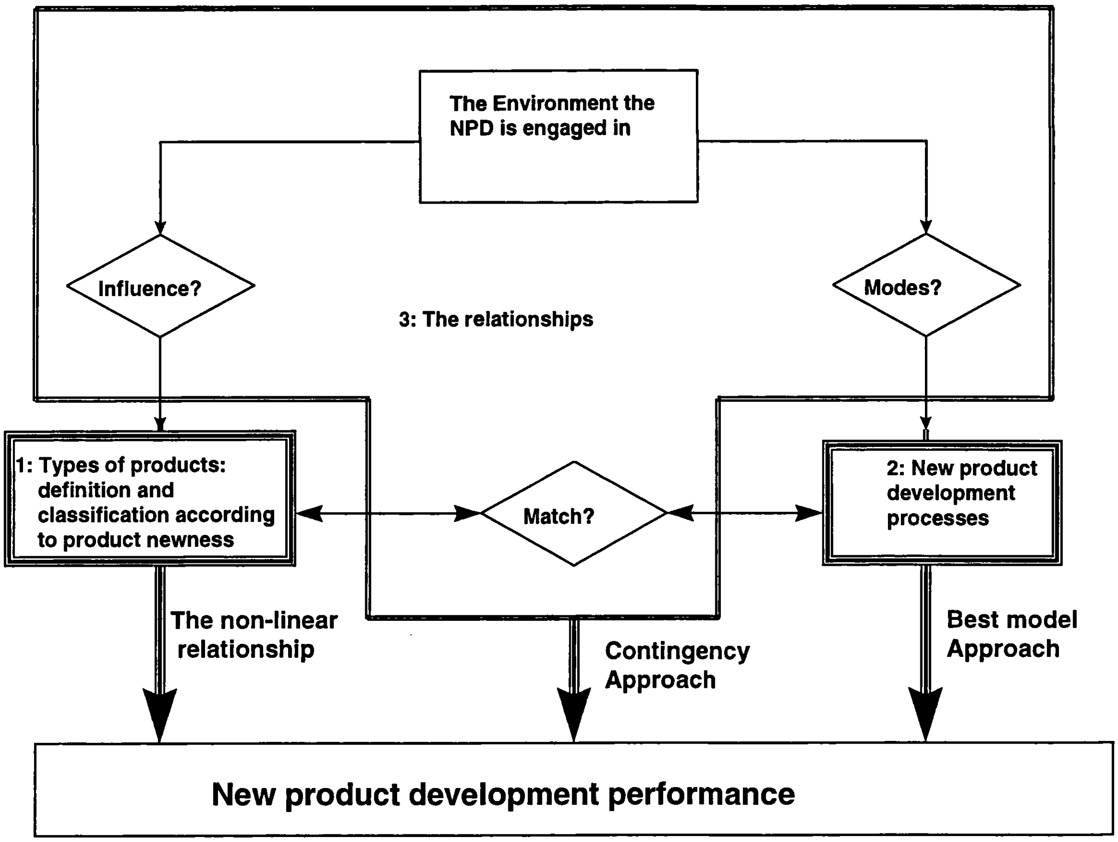


Fig. 3.2 Potential relationship between product newness and NPD processes

Because of the relatively complicated links, Fig. 3.2 may need some explanation. It is easy to see that there are three key components in Fig. 3.2. The first component is: types of products, definition and classification according to product newness, which has been described earlier in this chapter (Section 3.1). The second element is: NPD processes, which has been explored extensively in Chapter 2. Now the third element, the relationships in and around the first two elements will be described. The exploration will be done from several perspectives. As it is shown in Fig. 3.2, on the upper left corner the influence of the environment on product newness will be described. Correspondingly, on the upper right corner, the influence of the environmental factors on NPD processes will be encapsulated. Going down on the lower left part of Fig. 3.2., an examination between the relationship of product newness and NPD performance will be given. The findings by Kleinschmidt and Cooper (1991) may suggest the existence of a non-linear relationship that demands the adaptation of the match between product newness and NPD processes. Then this chapter will go on to explore the remaining part of Fig. 3.2, that is various types of matches between product newness and NPD processes which may differentiate contingency approaches and best practice approaches in the sense of getting a better NPD performance.

Starting from the 'influence' side on the upper left corner in Fig. 3.2, Ali's work (1994) provided an overall picture of the relationship between the environmental factors and the selection of new products according to their newness, in his words, the nature of product development. Two kinds of new products were identified: pioneering products and incremental products. The former was defined as products with major technological breakthroughs while the latter, was defined as product line extension or modification of existing products.

Based on the literature review, Ali (1994) concluded that the nature of product development was influenced by firm or industry characteristics, marketing characteristics, and innovation characteristics. Firm or industry characteristics included structure variables like size, entry barrier, incumbent market leader, and behaviour variables such as entry timing and licensing.

Marketing characteristics included technology variables (such as opportunity and sequence of innovation), and competition variable (rivalry) and customer variable (adoption).

The selection of pioneering products was suggested to be positively related to

- Firm size: Development and introduction of pioneering products were more likely to increase with firm size up to a certain point;
- Industry with moderate entry barriers: companies in an industry with low-entry barriers may not recover full investment costs and profits from development;
- Potential entrants: new entrants were likely to opt for a really new innovation which promised the winner a large share of market; such firms enjoyed a relative benefit from high-variance strategies and were affected differently by cannibalisation than were incumbents;
- Consumer durable industry: the consumer durable industry will have more pioneering products than would the consumer non-durable industry because of higher technology complexity and more opportunities of achieving product differentiation;
- Industry with rapid technological change: industries where rapid technological change shortens the product life cycle and stimulate the development of a stream of pioneering products;
- Number of firms in the industry: competition and not co-operation will induce innovation, as the number of firms in an industry increases, the rate of introduction of pioneering products increases;
- Products with high probability of early discovery.

Similarly, the selection of incremental products was derived to be positively related to

- Industry with low or very high entry barriers;
- Incumbent market leaders;
- Consumer non-durable industry;

- Decrease of the number of firms in the industry.

As to the behaviour, the third and fourth entrants were said to have greater likelihood of success than the first two pioneers and the followers. Ali (1994) suggested that different types of new products had different objectives, different marketing programmes, and were introduced in different environments. That was a clear indication that different types of new products needed to be developed in completely different modes. But the article did not provide an answer on how different types of new products were related to different product development processes.

Returning to Fig. 3.2 and the 'modes' perspective of the upper right corner, it is interesting to notice the work of Miller and Blais (1993). According to Miller and Blais, modes of innovation were stable patterns that referred to the repertoires of behaviours that firms employ to adapt to, match or transform their environment in order to gain competitive advantages.

Four modes of innovation were identified across six industry sectors:

(1) The science based product innovation mode

Firms tended to get technology leadership mainly through internal R&D. The organisation structure was flexible and the firm tended to be of moderate size. This slightly deviated from Abul Ali's proposition that the likelihood of choosing pioneering products was likely to increase with the firm's size.

(2) The entrepreneurial fast-track experimentation mode

The mode of innovation of firms in this class was characterised by a high degree of experimentation to develop a continuous flow of improved products and improve production.

(3) The global cost leadership mode

Firms contributed mainly on the process innovation to reduce the overall cost.

(4) The reactive mode of reliance on technology and process adoption.

The study confirmed that environmental factors had a strong influence on strategy, choice of products, and product development structure and process. Because their study was not based on the project level, it was still difficult to get a clear picture of how different kinds of products were developed differently.

In summary, based on an extensive literature review, Ali (1994) concluded the decision to develop different kinds of products (pioneering or incremental) was strongly influenced by industry characteristics, market characteristics, and innovation characteristics. On the other hand, Miller and Blais (1993) suggested NPD processes can be classified or clustered according to industry characteristics and other environmental factors. Putting these two research findings together, it was not difficult to find the driving force of various environmental factors on both product newness and NPD processes. Regarding the strong influence of these environmental characteristics, one would ask a further question, what kind of relationship exists between product newness and NPD processes? In other words, should different NPD processes be employed for different types of products according to their newness? If so, in what way should the process differ?

3.3 EXISTENCE OF THE IMPACT OF PRODUCT NEWNESS ON NPD PROCESSES

Return to Fig. 3.2 and the "non-linear relationship" of the lower left corner, Kleinschmidt and Cooper (1991) examined the relationship between product newness and NPD performance. The results strongly suggested that different kinds of "new" products need different treatments (NPD processes).

On the basis of Booz, Allen, and Hamilton's classification, three kinds of new products were defined by Kleinschmidt and Cooper (1991)

. *Highly innovative products, consisting of new-to-world products and innovative new product lines to the company.*

. *Moderately innovative products, consisting of new lines to the firm, but where the products are not as innovative; and new items in existing lines for the firm.*

. *Low innovative products, consisting of all others: modification to existing products, redesigned products to achieve cost reductions; and repositionings.*

Kleinschmidt and Cooper (1991) analysed data from 195 new product cases of 125 industrial product firms. The result showed that innovativeness was both a negative factor and a positive factor to the success of NPD. Both highly innovative products and low innovative products shared a relatively high success rate, while moderately innovative products had a low success rate. That is, a U-shaped non-linear relationship between the degree of newness of products and product successes existed. "*The U-shaped relationship is proved to be strong, striking and statistically significant*". That might be a key contribution of their study because it claimed to have solved a problematic issue that had plagued the authors for years (p 251). Indeed, their work can be regarded as the first empirical research on the impact of "product newness". However, there are two questions which need to be qualified further:

1. Whether the U-shaped relationship is universal or just limited to the Canadian cases. According to Parry & Song 1994, no evidence of a U-shaped relationship between product innovativeness and success was found. On the contrary, they detected a linear relationship based on a Chinese sample.

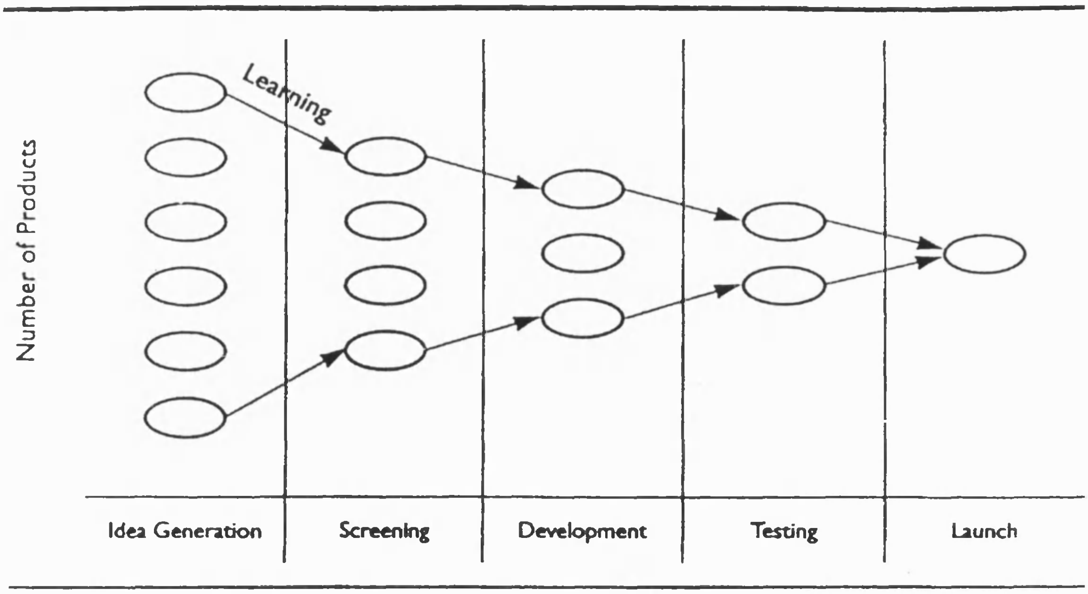
2. The newness classification is based on Booz, Allen and Hamilton's categorisation. However, the" new product line" proved to be a troublesome category. The authors found that both "me too" products and "very innovative" ones, for example, belonged to the same "new product line" category that may need additional measures to separate. The reclassification need some judgement of the researchers which may not be easily replicated in other studies.

3.4 THE IMPACT OF PRODUCT NEWNESS ON NPD PROCESSES

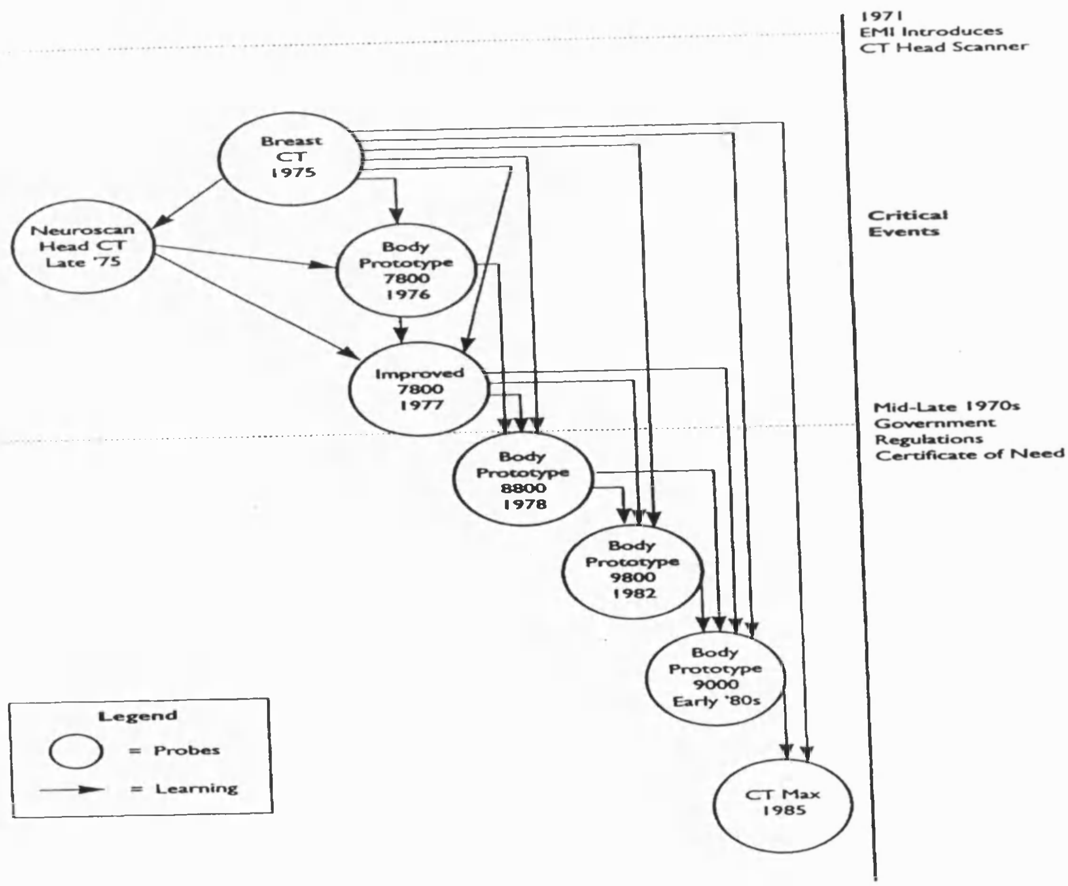
3.4.1 The impact of newness on probing and learning layer

In the last chapter, four layers of NPD processes were summarised. They are, probing and learning layer, entity layer, relationship layer, and attribute layer. The first layer regards NPD processes explicitly as a learning process, which transforms five types of product forms along the time horizon: IDEAS, CONCEPTS, PROTOTYPES, PRODUCTS IN TRIAL, and PRODUCTS LAUNCHED.

Indeed, the development of new products as a learning process has long been addressed (Zaltman et al 1973). Understandably, the more radical an innovation is, the more learning and unlearning take place. Therefore the probing and learning layer in NPD model may not follow the exact sequence of IDEAS to CONCEPTS to PROTOTYPES to PRODUCTS IN TRIAL to PRODUCTS LAUNCHED. More learning means more probing, that is, more experiment, and therefore more iterations. Lynn, Morone and Paulson (1996) compared the learning process in what they called the 'conventional NPD process' to the learning process in the new paradigm they are going to build which stands mainly for "discontinuous product development". The comparison is shown in Fig. 3.3. Fig. 3.3a shows the conventional NPD process, a model as familiar with as the one in Booz, Allen and Hamilton (1982). Fig. 3.3b shows an example of the discontinuous NPD process, GE's probing and learning process.



(a) The conventional NPD process



(b) GE's probing and learning process

Fig. 3.3 Conventional and discontinuous NPD process (From Lynn et al 1996)

In addition to the intensity of learning taking place in NPD, it can be seen from Fig. 3.3 that the impact of product newness may influence, more importantly, the length of iteration. That is, the iteration process happened not only from concepts back to ideas, or from prototypes to ideas, but also from products in trials back to ideas or even from products launched back to ideas. It is on this basis that Lynn, Morone, and Paulson (1996) suggested over past 25 years, the theory of NPD was analysis-driven and aimed at getting the product right instead of maximum learning. The conventional theory of NPD, as they claimed, was inappropriate for discontinuous innovation even for the vocabulary used to describe the conventional process.

> *"The discontinuous innovation process is thus a process of successive approximations that has to be managed not through analysis, but by experimental or quasi-experimental design. The key questions become not what is the right product, but rather, what steps can we take that will generate maximum information about the product and market and how do we incorporate that information into our product development. The logic is not to strive to get "it" right, but to strive to maximize learning. (p28)"*

Although the differences between the existing theory of NPD and Lynn et al's discontinuous processes might be exaggerated, Lynn et al's work did explain convincingly that product newness did have an impact on the NPD process.

3.4.2 The impact of product newness on entity layer

Recall that the entity layer consists of two sub-layers: player layer and activity layer. The player layer consists of relevant persons or parties who participate in the NPD, it concerns how these players are organised and what characteristics they have and what role they play. The activity layer consists of relevant activities (or stages) which are part of the NPD. Past research on the impact of product newness into the entity layer can also be divided into two streams: the impact of newness on the player layer and the impact of newness on the activity layer.

3.4.2.1 The impact of product newness on players

It is no exaggeration to say that most of the related research concentrates on the first stream: the impact of product newness on the player layer, especially on the dimension of how players in NPD are organized. Among them, Normann's (1971) comparison of requirements for variations (modification of existing products) and reorientations (radical products) in NPD has been extremely influential. Variations involve only minor changes in the task systems that can be accommodated without major adjustments within the existing political system. They can be handled with few changes in the cognitive orientations of organizational members. In contrast, reorientations involve basic changes in the task system; they necessitate new types of structures, and cognitive systems are needed. Norman suggested that reorientations introduce more uncertainty and therefore require more organizational change, more entrepreneurship, and greater involvement of top management than variations do.

Zaltman *et al* (1973) inferred that the more radical an innovation, the more learning and unlearning must take place, and therefore more modifications must be made in existing structures and processes. That is, product radicalness is likely to have a major impact on what organizations must do to implement successfully. As defined by Nord and Tucker (1987), routine innovations refer to the introduction of something that while new to the organization is very similar to something the organization has done before. A radical innovation, in addition to being new to the organization, is very different from what the organization has done before, and is therefore apt to require significant changes in the behaviours of employees and often the structure of the organization itself. They confirmed Zaltman *et al*'s discovery by observing one borrowed innovation: a Negotiated Order Withdrawal (NOW) account implemented on the same day in twelve financial organizations. NOW is being seen as radical to some organizations and routine to others. They concluded that structures that make it possible to adapt quickly to knowledge gained through trials and errors should aid radical innovation. As to routine implementations, they suggested the importance of understanding the processes by which organisations quite appropriately draw on their own past experiences.

"The overall result is apt to be that the experience with the innovation becomes mapped into the new arrangements"

Most recently, Olson, Walker and Ruekert (1995) addressed the issue directly. Their study included 45 new products from 24 firms being developed in the last 3 years that covered a variety of industrial products. To answer the research question of whether any one type of co-ordinating structure is likely to be uniformly successful in delivering more creative new products, cutting development time, and improving product success in the marketplace across all kinds of development projects, a contingency structure-performance model was built. Seven co-ordination mechanisms during the development of products were identified which constitute a continuum with the most formal structure on one end and the most informal structure on the other side:

(1) Bureaucratic control/hierarchical directives

The most formalised and centralised, and the least participative mechanism relies on standard operating procedures and the oversight of a high-level general manager to co-ordinate activities across functions.

(2) Individual liaisons

In addition to some of the vertical communication flow found in bureaucratic structures, communications between different functional departments are carried out by assigned liaison individuals.

(3) Temporary task forces

Individuals from various functional departments are organised temporarily to finish tasks assigned in the NPD.

(4) Integrating managers

An additional manager is assigned to enhance communication and decision making between different functional departments.

(5) Matrix structures

Individuals are responsible to both a functional manager and a new product manager.

(6) Design teams

A set of functional specialists are brought together to work on a specific NPD project with much greater autonomy than temporary task forces.

(7) Design Centres

This structure pads on the other end of the continuum. It represents the most complex, decentralised and informal structure.

The study revealed a fit between the degree of formalness of co-ordination mechanism and the experience level the firms have. The latter is, according to Olson et al (1995), inversely related to the degree of product newness. The main conclusion is that the less experience the firm and the marketplace have with a new product concept, the more organic and participative the co-ordination mechanisms are used to manage the product development process. A fit between the firm's experience level and the co-ordination mechanism could yield better performance that is manifested in financial successes, timing of the project and personal psychological satisfaction levels of project participants.

The key contribution of their paper is that it revealed that no single NPD structure is uniformly efficient in the NPD process. This challenges the view that cross-functional teams are always superior. The degree of innovativeness or newness of the product being developed is identified as an important moderator of the impact of different co-ordination structures on the development process and its outcomes.

Although Olson at al (1995) provided evidence that strongly supported what they proposed the moderating role of product newness, there are common limitations of exploratory work of this nature. First, their sample was fairly small, only 45 cases were reported. Secondly, their convenience sampling procedure also limited the generalizability of the research findings.

3.4.2.2 The impact of newness on activities

The research into the impact of product newness on the activity layer of NPD process is far less than expected. There are few studies available in dealing with the problem of how product newness is related to NPD processes in the sense of how the NPD processes are carried out (Lynn et al 1996, Nord et al 1987). Of the few studies available, almost all of them are exploratory. Johnson and Jones's (1957) work may be regarded to be the first in this field. To them, newness has also two dimensions: new to the market (which was reflected in the later work of Booz *et al*) and new to the technology. With these two dimensions, eight diversifications were identified (see Figure 3.1). Johnson and Jones fit the eight categories into what Saren (1984) called The Department-Stage model. Development procedures were distinguished according to different types of products (the kind of newness involved in each case), which were characterised by the requisition authority and accounting procedure for expenditure. They are the first in the field who tried to handle different new products using different development procedures, although only the Department-Stage model was used which is regarded as out-moded in today's NPD activities (Hart and Baker 1994).

Most of the related studies afterwards focused on the relationship between the degree of newness and organizational structure changes. There are two papers which tackle the problem indirectly. One is Shrivastava and Soulder's work (1987). They suggested that the development of new products is highly contextual. Based on detailed studies with over 200 new product innovations in 50 US firms, their contingency model distinguished different contexts using three different transfer models: stage dominant model, process dominant model and task dominant model (see section 2.3.1.2 for a description of these three models). The contexts were expressed by seven untested hypotheses. The first two hypotheses are relevant here and are stated as follows:

P1. Among organizations facing highly uncertain technological and market environments, the use of task-dominant (TD) and Process-dominant (PD) models will lead to more successful technological innovations than Stage-dominant (SD) models.

P2. Technological innovation involving highly sophisticated and complex technologies will be more successful if they use the TD model instead of the SD or PD models. Innovations involving simple technologies will be more successful if they use the SD model than if they use the TD or PD models.

Although their hypotheses have yet to be tested, the key contribution of the model might be in indicating that different kinds of context accommodate different NPD processes. It is therefore recognized as one of the most modern NPD models (Coxhead and Davis 1992). The other paper is an illustrative article by Krubasik (1988). He pointed out that "*too often, managers respond with the same development strategy without considering the context in which they find themselves*". He suggested two key dimensions in considering different NPD strategies: the opportunity cost of missing a fast moving market window and the risk of entering a market with the wrong product. A product development map was drawn according to different combinations of these two dimensions. The IBM and Boeing and Ericsson examples were used to support his theory. When the opportunity cost was high, a crash program aimed at shortening development time makes sense. When the development risk is high, it is important to be certain that the product is 100% right at market launch. When both opportunity cost and development risk are relatively high, a step-by-step product line strategy might be appropriate.

3.4.3 The impact of newness on attribute layer

As suggested in Chapter 2, the usage of NPD processes as measured variables in the literature is relatively weaker compared to the other two research streams: success/failure explanation and modelling of NPD processes. There is no surprise that the empirical analysis into the impact of newness on the attribute layer of NPD processes is not widely available. However, Van De Ven (1991) suggested that process as categories of concepts was the most frequently used in the context of strategic process. Recent literature shows that much effort is being put into meeting the challenge of Brown and Eithenhardt's (1995) criticism of the lack of well measured constructs in NPD research (Song et al,1997). It is expected that more and more research will appear in this area.

As described in section 3.1. product newness is a subjective concept. Although intuitively and theoretically product newness should have an impact on the NPD process, there is no solid evidence (Lynn et al 1996, Clark & Fujimoto 1991, Nord et al 1987). As mentioned earlier in Olson et al's study (1995), a stronger relationship between product newness and formalness of NPD process was found, whereas Clark and Fujimoto (1991) did not confirm the existence of the impact of product newness using the sample of the automobile industry. Kleinschmidt and Cooper (1991) revealed the curvilinear relationship between product newness and NPD performance, while Parry and Song (1994) only found a linear relationship in a replicated study. These confusions showed that the impact of product newness on NPD process is not simple. There may also exist other influence factors such as difference in industry, differences in products. Product complexity, for example, may have a stronger relationship with the formality of NPD processes than product newness. Another aspect addressed in the literature is the multi-dimensionality of product newness. A product can be new to the company, while it is not new to the market. A product can be new in technology, while it is not new to the market. Although several articles used multi-dimensional measures of product newness, the multidimensionality of product newness was only used for the categorisation of new products. Kleinschmidt and Cooper (1991), for example, used both Booz, Allen and Hamilton's six category schemes and the three dimensional measures for product newness. They reduced the Booz, Allen and Hamilton's six categories into three, combining the three dimensional measurements plus the subjective judgement of researcher. By so doing, a parsimonious NPD category labelled low innovative new products, medium innovative products, and highly innovative products was obtained. But the procedure became less objective and therefore it is difficult to follow. Most importantly, valuable information was lost due to the procedure of categorisation. That might be one of the reasons in explaining the inconsistency between Parry and Song's replicated study (1994) and Kleinschmidt and Cooper's original one (1991).

. Product newness and linearity of NPD process

According to Zaltman et al (1973): "*It can be hypothesized that the more solution radical the innovation, the more likely problems will emerge in the process of implementation. Accordingly, the more solution radical the innovation, the more important it is to create feedback mechanisms that can identify and deal effectively with these emerging problems*"(p78). They inferred that the more radical an innovation, the more learning and unlearning take place, and therefore the more modification must be made in existing structures and processes. Thus more radical innovations may need more feedback and iterations during the NPD processes. More iterations are needed for newer products because major innovations are generally unpredictable and accidental in nature, whereas incremental innovations can be programmed or planned for in some way (Myres and Marquis 1969). These arguments suggested that:

H1: product newness is negatively related to the linearity of the NPD process, that is, the newer the product the less linear the NPD process or converse.

Eisenhardt and Tabrizi (1995) suggested that when predicable paths do not exist, simply increasing the number of design iterations improves the odds of success and thus accelerates the process. Thus one would expect

H1a: The higher the interaction between non-linearity in NPD processes and product newness, the better the performance of the product will be. In other words, the positive effect of the non-linearity of NPD processes on the performance of the product will be stronger if at the same time newness of the product is higher.

While on the other hand, more design iterations mean more delay and increased cost of NPD. The worst case was that not enough pre-development activities were done before the development. Then in the final stage it was realised that something was wrong in the design, and a late re-design had to be undertaken which inevitably increased the development cost. So in this case, sufficient pre-development studies would reduce the necessity of design iterations and which in turn would increase the odds of success. In formal terms,

H1b: Other things being equal, reducing the number of design iterations or increasing the linearity of NPD processes yields a better performance.

. Product newness and parallel level of NPD processes

Increasing the parallel level of NPD processes has been set as one of the major means to faster NPD. A variety of means and methods were used recently. Swink et al (1996) suggested that the overlapping of product and process development tended to happen less for product elements when product technologies were uncertain. Eisenhardt and Tabrizi (1995) argued that higher levels of project over-lap may be suitable for predictable, mature products such as automobiles and heavy industrial equipment, but they are less significant and even negative predictors of development speed for products such as personal computers, for which technology and markets are rapidly and unpredictably evolving. Besides, low product newness product suggests routine or non-significant modifications of existing products and it can be done in some programmed way, therefore it is easy to be compressed and accelerated via means such as concurrent engineering. In formal terms,

H2: Product newness is negatively related to the degree of overlapping in NPD processes, that is the newer the product, the lower the degree of overlap in NPD processes.

For the unpredictable nature of highly new product, trying different ways via overlapping activities means reducing the uncertainty of development and speeding up NPD processes, cutting the lead time and therefore yielding better performance (Reinersen 1992). While the newness of product is low, NPD processes can be realised in a planned way (Globe, Levy and Schwartz 1973). Therefore the effect on product performance of overlapping activities may not be as strong as when product newness is higher, that is:

H2a: The higher the interaction between the parallel level and product newness, the better the performance. In other words, the positive effect of overlap on product performance is stronger when product newness is lower.

When development uncertainty is under control, increasing overlapping means being able to reduce lead times and launch the product into the market earlier without involving considerable risk and therefore increasing the probability of success (Steinberg 1985). That is,

H2b: Other things being equal, increasing the level of overlapping yields a better performance.

. Product newness and formality of NPD process

Olson et al (1995) suggested that the less experience the firm and the market place have with a new product concept, the more organic and participative the co-ordination mechanism used to manage the product development process, and thus less formalised rules and operating procedures are used. This suggested that

H3: product newness is negatively related to the formality of NPD processes.

Naturally, a firm that is aware of the relationship between product newness and the formality of the NPD process would achieve better performance:

H3a. The higher the interaction between product newness and the formality of NPD processes, the better the product performance. In other words, the positive effect of a formal process on product performance will be stronger when the product newness is lower.

Role ambiguity can result because without more formal procedures the individual is likely to be uncertain concerning what tasks have to be performed. The lack of a more formal procedure would also lead to role conflict which would yield worse performance. Formal procedures also stimulate communications between project members and hence have positive impact on the commercial success of the project (Moenaert et al 1994). Therefore,

H3b: Other things being equal, increasing the formality of NPD processes yields a better performance.

. *Product newness and the role flexibility of marketing*

If a product is new to the market, it is important to know the target markets' requirement of the product. One therefore would expect marketing to play a more important role in the development process. The high degree of novelty in product dimensions also implies a reciprocal dependence relationship between marketing and technical people (Normann 1971). While to build and maintain this reciprocal dependence relationship, mutual trust and understanding is very important. It therefore requires more role flexibility in marketing. In formal terms:

H4a: The newer the product is to the market, the higher the role flexibility of marketing plays.

It is suggested that marketing people have less power in a highly uncertain environment (Workman 1993). In a high-tech setting like ICT sectors, understanding and coping with technological uncertainty is a central concern. The newer the product is to the technology, the more uncertain the NPD process would be, thus the less power people in marketing will tend to have (Workman 1993). Thus:

H4b: The newer the product is to the technology, the lower the role flexibility of marketing.

. *Product newness and the role flexibility of R&D*

If a product is not new to the company, R&D people should have a general familiarity with the customer requirements of the product. They may have greater opportunity to contact customers themselves. Customers, on the other side, more than often like to contact technical people in the firm (Workman 1993). In that case, R&D people are more likely to participate in marketing activities than when developing a product which is completely new to the company. In formal terms:

H5a: The newer the product is to the company, the lower the role flexibility of R&D.

For a new to technology product, the participation and co-operation of R&D personnel is recognised as very important (Griffin and Hauser1996). In fact, in the development of a new to technology product, R&D people often played a major role. In addition to the technical activities, many R&D people contact customers themselves (Workman 1993). In formal terms,

H5b: The newer the product is to technology, the higher the role flexibility of R&D.

The linkage of these hypotheses is summarised as Fig. 3.4 and will be explained briefly in the next section.

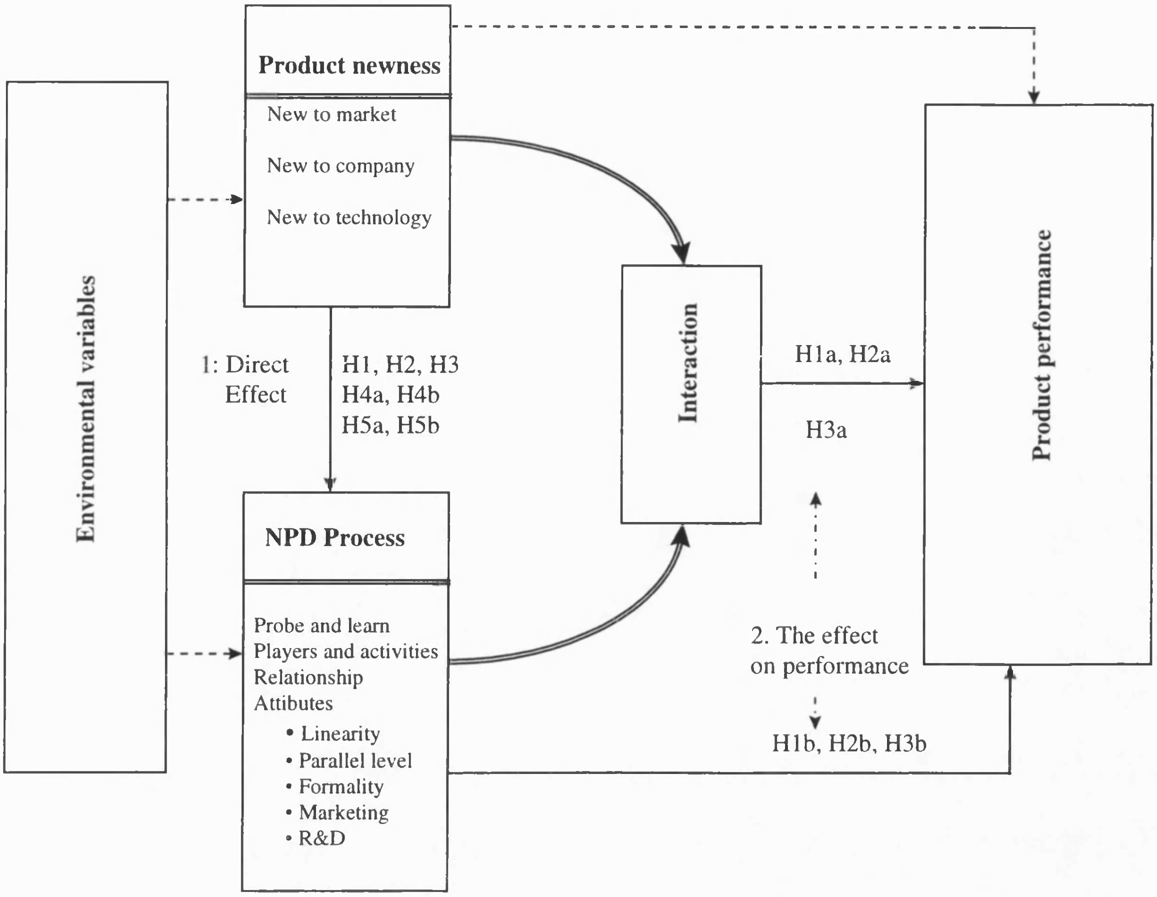


Fig. 3.4 A summary of literature review

3.5 A SUMMARY

In order to link the two concepts: product newness and the NPD process, this chapter suggested that product newness is a subjective concept characterised by multi-dimensionality. At least three dimensions should be considered: newness to market, newness to company, and newness to technology. The focus of this study therefore will concentrate on these different dimensions instead of on categorisation derived from them. Of the potential of product newness on NPD processes, evidence in the literature shows that product newness has an impact on NPD processes, although the relationship may not be simply linear. This suggests that different types of product need different NPD processes according to product newness. In a broader context, NPD processes may also be influenced by other factors such as firm size, product complexity, which are also the driving forces for firms in deciding what kinds of products (highly new, moderate, or not new) to develop.

The influence of product newness on NPD processes is unfolded in two perspectives. First, it influences the way NPD is carried out. Secondly, the interaction of newness and NPD processes may influence the outcome of NPD. These were presented in a set of hypotheses. A graphical summary of the hypotheses is shown in Fig. 3.4, which will be used as a conceptual framework in the forthcoming chapters.

As it is shown in Fig. 3.4, the influence of product newness was considered in three dimensions (newness to market, newness to company, and newness to technology) on five perspectives of NPD processes (linearity, parallel level, formality, role flexibility of marketing and role flexibility of R&D). The interaction between product newness and NPD processes was linked to product performance. The fundamental assumption is that variations in the attributes of NPD processes may have positive (or negative) influences on product performance depending upon differences on product newness. The direct influence of the NPD process on product performance was also explicitly presented . The solid line in Fig. 3.4 shows that the relationship between two linked objects will be tested in the forthcoming chapters via those hypotheses specified in the last section of this chapter, while the dashed line expresses that the relationship will be explored without prior assumptions. The next chapter, Chapter 4, will describe methodological issues encountered in this research.

Chapter 4 Research Methodology and The Primary Data Collection

Whereas Chapter 2 set up a generic view on NPD processes, Chapter 3 examined the relationship between NPD processes and product newness. The interaction between NPD processes and product newness was linked to performances of products. Hypotheses regarding five different perspectives of NPD processes were then formulated and summarised in a conceptual framework at the end of Chapter 3. The purpose of this chapter is to address the methodological issues in examining these hypotheses in the context of the British Information and Communications Technology Industry and to describe methods used in the primary data collection. Some researchers may be fortunate in their research. They select a research design and carry it through without substantial change. Many others have to attune themselves continuously in the research process toward the direction they think is most appropriate. That is, the research process, being new to the researcher, is itself a probing and learning process. It is therefore the intention of this chapter to make the research procedure of this study as transparent as possible without adding too many trivial details.

Although there is no intention to present a comprehensive description of the various problems encountered in this research, the first section of this chapter will present an overview of the research procedure and will highlight key considerations in the research design. Because the study used mainly a quantitative, survey based research methodology, the first and most important question therefore is how to measure those constructs. Section 4.2 will present measurement issues of each individual construct. The rationale of using these constructs will be briefly discussed. An issue closely related to *the measurement of constructs is the design of a good questionnaire. This took an unexpectedly long time in this research and Section 4.3 will describe the effort that was put into developing it.*

Another key issue is the representativeness of the sample as this is a common problem with many survey oriented studies. The difficulty arose in that there is little information about the population which is growing and changing from time to time. Section 4.4 will describe how a stratified sampling procedure was used and why the optimal allocation method was chosen to gain the maximum amount of precision.

The whole survey design process followed the theory of Dillman's (1978) total design method (TDM). Although postal survey is the focus of this research, telephone support before and during the postal survey was provided. The research findings were validated through face to face interviews. Besides, this survey was set under the context of one industry and funding for the survey was limited. These characteristics made this survey adopt a slightly different path from Dillman's exact TDM procedure. Section 4.5 will highlight these considerations and will describe a unique procedure being carried out in this survey. Finally, post-survey interviews presented an opportunity for discussing the discovery with managers. Section 4.6 will describe a semi-structured evolutionary interview procedure. The description of the data collection procedure will provide a basis for discussions of data validation in the next chapter.

4.1 OVERVIEW OF THE RESEARCH METHODOLOGY

4.1.1 The research procedure

Finding a proper approach for a research topic is by no means an easy task and this research is no exception. This section will describe the procedure used by this research. In the context of marketing research, Churchill (1995) argued that "*all research problems require their own special emphases and approaches. Since every marketing research problem is unique in some ways, the research procedure typically is custom tailored (p81).*" Crawford's (1994) metaphor of carpenter and tool box on NPD processes (see Chapter 2) is certainly suitable for the design of marketing research as well.

The difficulty is indeed to find a balance between theoretical design and practicability. The key issue here is that to know what needs to be known and to minimise inevitable distortion. Although it is a very old topic, there has been a heated debate in past decades as to whether this goal can be achieved. The early debate seemed to reach the conclusion that social science is subjective, while the modern debate has made further attacks on the problem that all science is subjective (Hunt 1993). As for marketing research, it is not difficult to find from the research procedure that almost every step could be regarded as a struggle against subjectivity and bias in some sense[1]. While trying to fight against subjectivity, it is the intention of this chapter to make the research procedure as transparent as possible, at the same time without adding too many trivial details. The research procedure used in this study is shown in Fig. 4.1.

It can be seen from Fig. 4.1 that the study followed a hypothesis-evidence-modification route, which can be divided roughly into three stages. The first stage is hypothesis formulation. At this stage, hypotheses regarding the relationship between product newness and various perspectives of NPD processes were made. These hypotheses were presented in Chapter 3. In addition to content analysis of past literature, repertory grid techniques were used in shaping important constructs of NPD processes and specifying hypotheses. The role of the analysis was heuristic and the usage of repertory grid here was very simple. The profusion of "best practices" accumulated a lot of NPD stories in literature which narrate how new products were developed and what made them a success. Thirty such case stories were selected in this study. These case stories inform the researcher intuitively from the perspective of 'anecdotal evidence' of the NPD process in various situations. The content analysis of literature revealed many constructs as described in Chapter 2 and Chapter 3. Comparing the NPD processes and their contexts (triading in the term of the repertory grid techniques) resulted in some new constructs. For example, "linearity of NPD processes", a concept described in the last chapter (See section 2.4.4) was originated from a comparison of three cases, Zantac (a new medicine), Baby Jogger (a novel chart) and Trantor (a tractor). A distinct difference between the development of Zantac from that of Baby Jogger and Trantor is the degree of iteration during the process. The lucky inventor of Baby Jogger may have an 'at once' success, while Zantac experienced several major modifications. A continuation of the comparing process(or triading) elicited a number of such constructs of NPD processes and their contexts. The origin of some of the constructs was found in the literature. Eighteen constructs in total were elicited. These constructs are all bipolar concepts. Measurement criteria for each construct were then developed. Returning to the 30 cases, each case was analysed according to the 18 constructs. For example, a description of the linearity of the development process of Zantac was extracted from the case story.

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[1] The appropriate achievement might be so-called 'disciplinary objectivity" or 'procedure objectivity'. Please see Appendix I for further discussion.

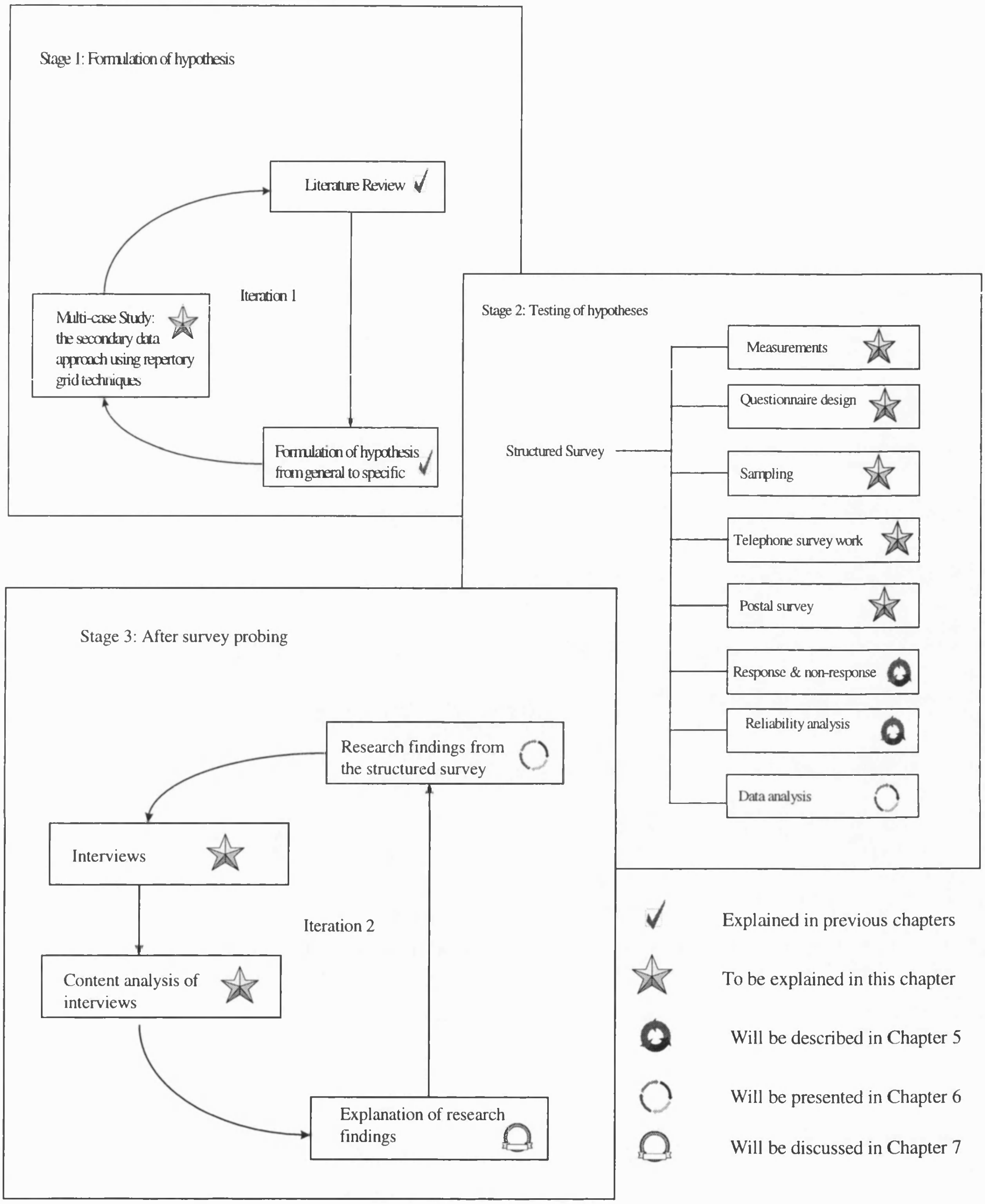

Fig. 4.1 The research procedure of this study

In total there are 18*30=480 description items. The result of which is the so-called repertory grid in which rows represent cases and columns represent constructs. The cells contain descriptions of particular constructs in particular cases. Although this analysis can not be used in proving the hypotheses proposed in the last chapter, it inevitably played a heuristic role in the drafting of those hypotheses. A further analysis of the multi-case study, however, can be found in Appendix II.

The second stage is hypothesis testing, which followed a series of steps:

- Constructs appearing in proposed hypotheses were operationalised.
- A population database for the British information and telecommunications technology industry was built.
- On the basis of the population database, a stratified random sample was drawn.
- A structured questionnaire was designed and pilot tested.
- Telephone and postal means were used to collect the data. Procedures that were used to carry out telephone and postal survey work were also structured and well documented. Responses and non-responses were closely monitored during the data collection process.
- Reliability analysis was then carried out before the data analysis began.

The third stage comes after the survey, that is, validation and explanation of the result. While a quantitative approach has the advantage of relatively clear standards and normal processes, at the same time it keeps researchers a distance from the researched. It is beneficial to talk to the respondents if possible, which can make the researcher 'feel', 'smell' and 'sense' things by direct contact in the field (Mintzberg, 1979). After the data analysis was carried out, a handful of face to face interviews were conducted in this study to get a better understanding of the results and a feeling of 'being there'.

Basically, this is a serial process with three stages related closely with each other. The core linking element which these three stages work on is the conceptual framework summarised at the end of previous chapter. While stage one produced such a conceptual framework, stage two used a structured survey to test it and stage three provided further evidence to explain it. As for the relationship among these three stages, the output of each previous stage is the pre-condition of the following stage, with some overlap. For example, measurements for constructs were developed almost at the same time as the process of hypothesis formulation. And modification of the research procedure happened from time to time. This will be explained as follows.

4.1.2 Design iterations in the research process

As with most positivist research methodology, this study followed a hypothesis evidence route. However, as with many other researchers, the formulation of the research methodology is not straightforward. The research process itself is a probing and learning procedure. Two research iterations occurred in the research process as it is shown in Fig. 4.1.

The first design iterations occurred in the formulation of hypotheses. Through an extensive literature search, a picture of what a NPD process is appeared. Relating product newness to NPD processes proved to be difficult. First, being a very complicated process as it was shown in the last two chapters, it is difficult to present a comprehensive picture in a simple way. One of the problems, for example, is how to determine which construct is relevant in NPD processes? Secondly, contrary views were found regarding the impact of product newness on NPD processes. The fundamental question here is that, does the impact really exist? The direct influence of this question on the research design is that it generates a feeling of needing rich anecdotal evidence. This favoures qualitative research. Thirdly although the research in NPD area has boomed in the past four decades, most researches concentrated on incremental products. It is only recently that research into the development of really new products received more attention (Lynn et al, 1996). Nevertheless few empirical research results that deal with the impact of product newness on NPD processes are available. Given all of these difficulties, it is not difficult to understand that modifications and re-constructions to the design process as shown in Fig. 4.1 were inevitable.

The paucity in the literature relating NPD characteristics and product newness proved to be a problem in identifying what were the important attributes of NPD processes while considering product newness. One of the ways intended was to explore it directly in the field. The other method was to explore the literature more thoroughly. The latter efforts proved to be futile. Adoption of the former alternative would dramatically change the nature of this study even if it proved possible to do it[2]. The compromise adopted was to search the field indirectly from the literature, that is, using a secondary data analysis (multi-case study as it is shown in Fig. 4.1 and illustrated in Appendix II). There are several advantages of doing so. First it provides different information from a general literature review. Instead of facing propositions and arguments, descriptions of individual product development cases were collected. These individual cases provided greater possibility of re-organising and re-analysing those 'real' NPD processes in a desirable way. Secondly it provided rich text in contrast to general survey data. Anecdotal evidence can be found in text description for the secondary data, especially those success or failure NPD stories. Besides, these stories in the literature use multiple narratives of neutral observers such as reporters, experts and students of the market. In contrast, surveys tend to rely on self-reports from one or two informants in the firms being studied. Thirdly it produced more than a mere 'pilot' test. Secondary data in the literature provides wider perspectives such as the context NPD is engaged in, the accidental factors, government regulations, etc. Indeed, the

[2] Two practical reasons also deterred consideration in going to the field directly: length of time spend in finding a proper company and the extreme difficulty in getting a good access because of no established contact at the moment this research began.

secondary data study in this research provided two options. The first, of course, was that of keeping the research procedure as it is shown in Fig. 4.1, that is, a structured survey based approach. The other option was that of picking up the six different NPD approaches that were identified in the secondary research and examining the effectiveness of these approaches at different circumstances. A detailed description of these six approaches is described in Appendix II. The reason for choosing the first option will be discussed later in this section.

The second iteration occurred when interviews were carried out after the postal survey. Right after primary data was collected and data was analysed, it was intended to do a number of interviews to get an explanation of the results apart from the rationale of the literature and the indirect multi-case study (the secondary data analysis). In addition, it is always in the interests of the quantitative researcher to get a reasonable explanation for those exceptional cases which are either influential points or in sharp contrast to the results expected. Design for each of these interviews was modified on the basis of previous interviews.

Having described a rough picture of the research procedure used in this study, the next section will discuss the research design briefly from a practical perspective.

4.1.3 Practical reasons for the research design

From Fig. 4.1, it is not difficult to understand that this study is mainly quantitative research with significant elements of qualitative enquiry. One reason for using such a research design arises out of practical considerations. As described earlier, during the process of this research, there was a chance of going 'purely qualitative'. After the 30*18 repertory grid was formulated, it was possible to carry out a cluster analysis which is the strength of the repertory grid technique. The result yielded six clusters from the 30 cases. Six distinctive NPD approaches were then encapsulated. Applying and validating such a typology would certainly be fascinating research. The alternative was not chosen partly because of the access problem. Without the guarantee of good access, the quality of the qualitative research would be in jeopardy. This is what had happened to this research. The prior condition of doing such a research, of course, should be having an awareness of the distribution of corresponding situations in the industry and being able to get good co-operation from the company. To satisfy the first condition proved difficult if not impossible. Because of the relative 'weakness'[3] of NPD in the UK's ICT sector (compared to its peers in US or other part of the Europe), major new product launch in ICT sector which appeared in the media were rarely UK originated[4]. Even if the first condition was satisfied, e.g. a secondary research by this study revealed that the Psion company has developed a series of new products, HP's UK division is very active in NPD, to meet the second condition (to get a good co-operation from relevant company) might still be a problem. In this study both Psion and HP UK's division were contacted via private relationships or formal channels, no positive response was obtained. The procedure of establishing such a contact also took a very long time. For example, the researcher contacted GPT from various channels. The message finally reached the strategy development manager who was very positive about the research design of this study. He proposed to negotiate on behalf of the researcher with the product managers in different sites of the country which represented a radical product development approach, a moderate product development approach, and an incremental product development approach respectively. However the negotiation took a long time. Considering that a much longer time still is needed to actually do the fieldwork, the approach did not seem suitable for this research. The research procedure adopted by the study proved to be successful at least in the sense of getting a good access without wasting too much time.

[3] At least this is the impression when secondary data analysis was going on.

[4] This argument was based on a search of two CD-ROM product: European Business ASAP and FT-Mcarthy in recent five years, which picked up less than 10 items describing the UK's ICT new product launch.

In summary, having described briefly the research procedure of this study, changes in the research design are discussed. This research is to be quantitative research with qualitative components. In the forthcoming sections, as it is shown in Fig. 4.1, issues concerning the collection of the primary data will be discussed in turn.

4.2 MEASUREMENTS OF CONSTRUCTS

Finding proper measurements for constructs is a crucial issue in a sample survey. The computer jargon "rubbish in and rubbish out" clearly indicates that an inappropriate measurement would cause spurious results. Therefore it is important to follow a standard procedure to build proper measurements for constructs or variables to be measured. In this study, the measurement building procedure outlined by Churchill (1979) was carefully followed to build measurements of constructs. In the first instance, literature was searched to identify scales and items that might be used in this research. It was found that measurements for most constructs required in this study (as it was shown in Fig. 3.4) existed in the literature. It turned out that only two NPD process variables, the linearity of NPD processes and the parallel level of NPD processes, needed to be developed.

The scales used in this study are either the 5 point Likert scale or the seven point semantic differential. The five point Likert scale consists of a series of statements that expose a favourable or unfavourable attitude toward the concept under study (e.g. the product is new to the company). The respondents were asked for their level of agreement or disagreement with each statement. The rating was from 1 to 5 with strongly disagree rated 5 and strongly agree rated 1. The seven point semantic differential scales consisted a series of opposite bipolar statements with one end rated as 1 and the other end rated as 7. Both these two scales are very popular in marketing research. Both of them are suitable for the design of closed questions, therefore they enjoy the advantage of being easy to respond to. In addition to those considerations, the 5 point

Likert scale is used because many measurement items used in this study are adopted from existing literature which originally have 5-point Likert scales (e.g. the formality of NPD processes followed Moenaert et al 1994). Another advantage of five point scales is that it is very tight and space saving. The use of seven point semantic differential was limited to only two concepts not covered in the literature: linearity of NPD processes and parallel level of NPD processes. The reason for using 7 point semantic differential was due to the necessity of constructing bipolar statements (parallel vs. sequential, linear vs. nonlinear). Another consideration is purely out of intuition, that is, the efficiency of semantic differential statements in delivering complicated dichotomy messages.

For the precision and parsimony of the questions and integrity of the questionnaire, the scales used for multi-item constructs were limited to the 5 point Likert scale and the 7 point semantic differential, although it has been suggested that a positive relationship existed between the number of scales points over the normal range and the reliability of the measure (Churchill and Peter 1984).

The unit of analysis in this study was the individual NPD project, therefore the NPD project was the basis all the constructs were measured upon. As it is shown in Fig. 4.2, it requires information about the product performance on the market, the newness of the product, and various characteristics of the NPD process. In order to answer these questions properly, it was supposed that the respondent had an in-depth knowledge of the development procedure of the product. In the survey the respondent was asked to nominate a product he/she had worked on. One advantage of doing so was that the respondents could choose new products they were familiar with. Therefore it helped the respondents in answering specific questions in the questionnaire. The disadvantage was that the choice of the product can not be controlled by the researcher.

This section will present measurement items of these scales as outlined by the conceptual framework in section 3.4. A list of scales is shown in Fig. 4.2. Reliability analysis of these scales, however, will be presented in the next chapter.

The Performance scales
- Market performance
- Financial performance

Product newness
- Newness to market
- Newness to company
- Newness to technology

NPD process scales
- Parallel level
- Linearity
- Formality
- Role flexibility of marketing
- Role flexibility of R&D

Other variables
- Product complexity
    - Internal complexity
    - External complexity
- Environmental variables
    - Types of products
    - Types of organisations
    - Strategic considerations of the firm in NPD
    - Location of NPD

Fig. 4.2 A list of scales

4.2.1 The performance variables

As it is described in Chapter 2, section 2.2, research on the success and failure of NPD has been booming in recent decades and many factors have been found to be critical to the success of new products. Apparently, one of the key issues is how to evaluate the success and failure of new products. Griffin and Page (1995) suggested,

> *"However, even with all the research which has been done in this area, it is difficult for a firm to define whether in fact a new product is successful. Using the result*

from previous research published on measuring SF[5] as an aid in determining the "best" measures is confusing".

At the heart of the problem is the multi-dimension nature of product development performances (Cooper and Kleischmidt 1995, Hart 1993). More than 75 distinctive measures of success have been used by firms and academics with little or no consensus across either group (Griffin and Page, 1993). Griffin & Page (1996) concluded that the most appropriate measures for project-level success differ depending upon the strategy of the project (or product newness in terms of this research). They recommended three or four "most useful" performance measures for each project strategy that is based on Booz, Allen & Hamilton's classification. These "most useful" success measures can be grouped into two dimensions:

Market success measures (4 items)

- *Degree to which the project met market share goals*
- *Level of customer acceptance*
- *Level of customer satisfaction*
- *Degree to which the project provides a competitive advantage*

Financial success measures (3 items)

- *Degree to which the project met profit goals*
- *Degree to which the project met margin goals*
- *The current estimate of Return-On-Investment(ROI) on the project has met original criteria*

4.2.2 Measurements of product newness

The concept of product newness is described in section 3.1. Three variables were used to describe newness. They are: newness to market, newness to company, and newness to technology.

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[5] Success and Failure.

The newness to market was measured by six 5-point Likert items as follows:

- *The new product was mainly purchased by our existing customers*
- *There were no new competitors at all for this product at its launch*
- *It was targeted to satisfy a new market for us*
- *We organised a new sale force particularly for this product*
- *Completely different media types of advertising/promotion programme were used for this product*
- *New methods were used for market research in its development*

An internal consistency of this index (Cronbach Alpha) was reported as 0.827 (for 0-10 scaled questions in Kleinschmidt & Cooper, 1991)

Newness to company was measured by four 5-item Likert scales as follows:

- *This product belongs to an existing product category of our organisation*
- *The technology was already embodied in our organisation before the product development began*
- *This product needed little modification of existing engineering/design work*
- *There was almost no modification of existing manufacturing processes*

The Cronbach Alpha was 0.774 in Kleinschmidt & Cooper (1991)

Newness to technology (according to Afuah and Bahram, 1995) was measured by two 5 point Likert scales as follows:

- *The key ideas that make this product have significantly advanced existing knowledge of the current technology capability*
- *The linkage between the key ideas of the product have significantly advanced existing knowledge of the current technology capability*

4.2.3 NPD process variables

4.2.3.1 Parallel level of NPD processes

The measures for the parallel level of NPD processes and the linearity of NPD processes were developed during this research. The linearity of the NPD process was found important via multi case study (described in section 4.1.1) in Jin, Birks, and Targett (1996).

Each of them was measured by five seven-point semantic scaled items. Because of the complexity of these two concepts, the respondents were presented a simplified version of the layered NPD model that was developed in Chapter 2. The simplified model reflects mainly the learning and probing layer and the activity layer of the synthesised view. The major simplification is as follows. In the layered model of Chapter 2, different product forms (e.g. ideas) are major components of learning and probing layer. In the simplified version of the layered NPD model, the different product forms at the same time represent also different development stages or activities carried out around these product forms.

The reason for such a simplification is obvious. The main consideration here, of course, is to explain a complicated concept via words and graphs clearly to an audience who know nothing about this research and who have every reason to refuse to read it once they find it difficult to get through. Therefore it demands simplicity of the style, readability of language, succinctness of description. That is the number of terms used in describing the model should be reduced to minimum on condition that the understanding of measurement items is not undermined.

With the help of graphic presentation, key items of the model were explained in simple language. Then the respondent was asked if the development processes he or she reflected had experienced such key activities or stages. One of the main purposes of asking this seemingly irrelevant question was to make sure that the respondent read and understood the meaning of these terms and then being able to answer the questions followed, which apply the model to construct scales measuring the degree to which overlapping activities and iterations happened during the NPD process the respondents nominated. This strategy proved successful. During the qualitative pilot test stage (will be described in next section) and the pilot test stage of the questionnaire design, no respondents reported difficulty in answering these complicated questions.

The simplified model used in the survey is shown in Fig. 4.3.

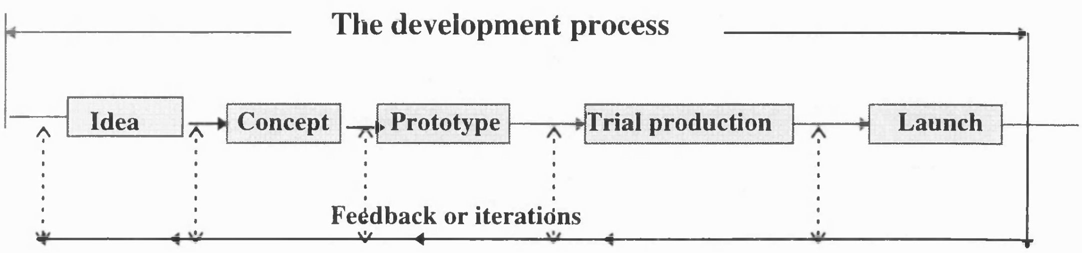

Fig. 4.3 A symbolic model for new product development

The explanation for the key terms was as follows:

Where **Idea** *refers to a stage or activities to generate and screen product ideas,* **Concept** *refers to a stage or activities in which a refined product idea was generated and tested to determine consumer acceptance*, **Prototype** *refers to a stage or activities in which prototypes of the product were designed and tested*, **Trial production** *refers to a stage or activities in which a small amount of products were produced.* *A product development may experience all or part of these stages. The following questions concern the sequence of these activities and the iteration that occurred during the product development process.*

Then the respondents were asked an easy question:

Did the development process have a distinct <u>Idea</u> Stage/ <u>Concept</u> stage/ <u>Prototype</u> stage/<u>Trial Production</u> stage ?

The purpose of that question was to make sure that the respondent understood the model in order to answer next questions. Five questions followed whose purpose was to measure the extent of parallel levels of the NPD process.

Please indicate the extent of overlap of the various stages or activities (Circle the most suitable number that shows which extreme you tend towards).

• *The idea stage and the concept stage were carried out in sequence, there was almost no overlapping*	*1 2 3 4 5 6 7*	*The two stages were conducted almost at the same time*
• *The concept stage and the prototype stage were carried out in sequence, there was almost no overlapping*	*1 2 3 4 5 6 7*	*The two stages were conducted almost at the same time*
• *The prototype stage and the trial production stage were carried out in sequence, there was almost no overlapping*	*1 2 3 4 5 6 7*	*The two stages were conducted almost at the same time*
• *The idea stage and the prototype stage were carried out in sequence, there was almost no overlapping*	*1 2 3 4 5 6 7*	*The two stages were conducted almost at the same time*
• *The concept stage and the trial production stage were carried out in sequence, there was almost no overlapping*	*1 2 3 4 5 6 7*	*The two stages were conducted almost at the same time*

4.2.3.2 Linearity of NPD processes

Five more questions were followed to measure linearity of NPD processes.

To what extent do you think significant changes and re-designs took place (Circle the most suitable number)?

• *We re-defined the product concept a lot of times*	*1 2 3 4 5 6 7*	*The product concept remained unchanged (e.g. at least 5 times) since the first definition*
• *The concept stage and the prototype stage were interwoven with each other*	*1 2 3 4 5 6 7*	*There were no concept definition activities after the first prototype was tested*
• *After the prototype test, a new concept definition was formed for the product*	*1 2 3 4 5 6 7*	*No change was made after the prototype test*
• *No change has been made since trial production*	*1 2 3 4 5 6 7*	*At least 10 percent of the product design*[6] *has been changed since trial production*
• *The product design changed a lot of times during the development process (e. g. at least 5 times)*	*1 2 3 4 5 6 7*	*There were no design iterations, we followed an exact step by step approach.*

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[6] Where the 10 percent change as a threshold is from Eisenhardt & Tabriz's (1995) study about the computer industry.

4.2.3.3 Formality of NPD processes

The formality of NPD process was measured by four 5 item Likert scales. This was followed from Moenaert et al (1994).

- *The development process was totally unstructured: everybody involved in the NPD process was allowed to be creative and to do almost as (s)he pleased.*
- *There were precise dates for the start and the completion of the activities to be undertaken during the development process*
- *During the development process, project progress was formally monitored*
- *The development process proceeded by means of a well-documented plan of action.*

4.2.3.4 Role flexibility of marketing.

The role of marketing was measured by three 5 item Likert scales, which were similar to the scales used in Moenaert et al (1994).

- *Marketing personnel played a very limited role in the development process*
- *The marketing project members had a strong technical orientation*
- *Some of the marketing project members also performed technical tasks*

4.2.3.5 Role flexibility of R&D

The role of R&D was measured by three 5 item Likert scales (similar to Monaert et al , 1994).

- *R&D personnel played a very limited role in the development of the product*
- *The R&D project members had strong business orientation*
- *Some of the R&D project members also performed marketing tasks during the development of this project*

4.2.4 Other variables

4.2.4.1 Product complexity

The measurement of product complexity was addressed by two authors in NPD literature. Clark & Fujimoto (1991) array the problem in two dimensions:

. *Complexity of internal structure*

Number of distinct components and production steps

Number of interfaces

Technology difficulty and severity of the trade-offs among different components

. *Complexity of user interface*

Number and specificity of performance criteria

Importance of measurable versus subtle and equivocal dimensions

Holistic versus narrow criteria

This definition seems comprehensive but hard to use practically even in a single industry. In fact, Clark & Fujimoto (1991) used retail price and number of body types to indicate the product complexity. These two measures may be proper to differentiate the complexity of cars. But it is hard to apply to broader products across several industries. Griffin (1993) also presented the complexity issue in two dimensions: product complexity, that is, number of functions the product performs, and management complexity, the number of technologies or functional specialities across which the project must be managed. But Griffin's definition is not without problem. Take the Program Controlled Exchange, for example, the same number of functions can be expected for 1000 lines and 111,000 lines. But their complexity is rather different. Here Clark & Fujimoto's original two dimensions were used.

. *Complexity of internal structure*, including

. Number of people involved in the development of the product

. Retail price

. *Complexity of user-product interface*, including

. The extent of learning needed

. The requirement of consumer's mastering of specific knowledge.

4.2.4.2 Environmental variables

Apart from above constructs which were the primary concern in this research, several open ended questions were designed to understand the 'environmental' part of the new product development process. In the original design of this research, several lengthy measurements for environmental factors such as environmental hostility and environmental uncertainty were included. For the sake of parsimony these constructs were excluded in the final design.

Another consideration in not including those environmental variables was that this study focused on the "project level" and demanded in-depth knowledge and details of NPD "processes". On the other hand, the measurement of environmental factors is largely at the organisational level which may require informants to have different backgrounds. Therefore if these two sets of questions were combined in the same questionnaire, the problem of uncompleted questions may arise, which will finally make this survey unsuccessful. All of the environmental variables included were single item and 'qualitative' orientated. These variables were:

- Types of products: the respondent was asked to describe what the product is and what distinct features made this product 'new' than the existing products.
- Strategic considerations of the firm in new product development: the respondent was asked to enumerate three factors which he/she thinks critical for his/her firm in developing a new product.
- Types of organisations: the respondent was asked to identify what kind organisation he/she worked for.
- Location of new product development: the respondent was asked to state in which country the new product development process happened.

4.3 QUESTIONNAIRE DESIGN

This section will discuss the design of the major questionnaire used in the survey. There were two other questionnaires designed in supporting the implementation of the main questionnaire. They were: the questionnaire for telephone survey work (before the postal survey began) and the questionnaire for telephone support during postal survey. The design of the other two questionnaires will be explained in a later section (Section 4.5). The main questionnaire used in this study is shown in Appendix III. Its design procedure will be stated as follows.

It goes without saying that questionnaire design is a central issue in a postal survey which can make or break a study. The design of the questionnaire followed the principle highlighted in Payne (1973) and Dillman (1978). The check list developed in Sudman & Bradburn (1982) was used to make sure the quality of the questionnaire design. Specifically speaking, the design of the questionnaire was divided into four major steps:

First, ***the initiation stage***, which was carried out in parallel with the formulation of hypotheses (See Fig. 4.1 stage 1). At the initiation stage, ideas about what concepts to measure and the operational definition of concepts were explored. A strategic concern of the questionnaire design, for example, was whether the questionnaire can be answered by one respondent or whether it required the knowledge of many respondents who came from different backgrounds. For example, environmental uncertainty and environmental hostility had appeared in the first draft of the questionnaire. These questions may need a firm level knowledge and they were administered in other research targeting CEOs of large organizations (Khandwalla 1977). The first draft of the questionnaire was formed in November, 1995. A preliminary evaluation process was done via the transfer panel in May 1996.

Secondly, ***the development stage***, formal design of the questionnaire, began early in the September of 1996. At this stage many draft versions of the questionnaire were formulated and a major interactive evaluation process was conducted. The evaluation panel consisted of four members at the School of Management with expertise in IT management, questionnaire design, and in the field of new product development. Although the author is responsible for all the possible errors of the questionnaire, this valuable process of evaluation proved to be very helpful and was certainly a key contribution to the success of the survey.

The third stage was ***qualitative piloting***. Two people were consulted. One of them was a senior research executive of a marketing research company who had no knowledge of the nature of this research but had expertise and experience in questionnaire design, especially for the ICT market. After a face to face introduction, the respondent was asked to bring back the questionnaire to read. One week later the respondent was interviewed via telephone with a copy of the questionnaire in front of the phone. The purpose of the consultation was to know if the appearance of the questionnaire was proper and if the wording of the questions could be easily understood by a person who had no knowledge of this research. The other was a second year PhD student who held a MBA degree and had more than five years experience as NPD manager in a major British company. The respondent had a general knowledge about the nature of this research and had been exposed to the author's presentation in the Doctoral students' seminar and he had read the author's research proposal before. In order to understand the reflection of the respondent on each individual question, the respondent was asked to complete the questionnaire in the presence of the author. An informal discussion about the questionnaire was then conducted. Several changes were made after the qualitative piloting stage.

Finally, in the last stage, a ***postal pilot test***, was conducted that followed a similar procedure to the postal survey(see section 4.5.2). The pilot procedure was carried out as follows. In the first instance, 10 potential companies were found from the sampling frame. Each company's marketing manager/director was contacted. They were asked first if new product development was part of their company's business. If the answer was yes, they were requested to recommend the best person in the company to be contacted. The people recommended were then contacted via telephones, fax, letters as well as e-mails to explain the purpose of this study. Five companies with friendly respondents agreed to participate in the research. A covering letter with a four page questionnaire was thus sent to each of these companies and three completed questionnaires were returned. A telephone interview was followed to understand how the questionnaire was filled out, what the difficulties there were, how long it took, etc. No major problems were found. After the pilot test, a final version of the questionnaire was formed. The questionnaire was finally printed out on a piece of A3 folded paper in blue and blank. It is attached in Appendix III.

4.4 SAMPLING

As previously discussed, if proper measurements of constructs lay the foundation of the data analysis, questionnaire design is certainly essential to the success of the survey. All this might be done in vain if there is no good strategy for sampling upon which the representativeness of the final research findings lie. Although in the area of NPD research inappropriate sampling may not break a survey[7], the distortion of the final results due to bad sampling can not be ignored. The fundamental problems challenged this survey as well as any other NPD studies that use individual project as a basic analysis unit are that:

- It is difficult to know the basic characteristics of the population. One key index of the population in this study is product newness. However there is no knowledge of such population characteristics. Even getting some rough pictures is difficult. For example, it is almost impossible to have an accurate knowledge of how many products were developed in a fixed period, not to say where these products were produced or what these products are.

• A project is developed by a team of people. In a postal survey, usually a single informant was used. Therefore some kind of selection procedure should be used. But because of a lack of information on the projects, it is difficult to select from the population of informants.

Indeed, in a study like this, there is a hierarchy of populations to deal with. On the top of which are companies. In each company, a number of projects of NPD may be carried out and each project may be developed by a number of different people in the organization. The unit of analysis was the individual project, while the questionnaire could only to be filled in by the project members. But the contact information available more than often is the company in general instead of NPD projects or relevant NPD people. These characteristics made sampling a difficult task.

Due to these difficulties, it is not uncommon to read empirical studies in this area which either use convenience samples or enumerate every possible project (or company) if time and budget allow. In this research, it is intended to find some ways to use a relatively standard sampling procedure.

The sampling followed a seven step procedure as described in McDaniel and Gates (1993). That is, defining the population of interest first; choosing data collection method second; then choosing the sampling frame; selecting a sampling method; next determining sample size, developing and specifying an operational plan for selecting sample elements, and finally executing the operational sampling plan.

While there is no intention to describe the whole procedure in detail, important considerations in the sampling procedure will be covered in this section. Especially,

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[7] In the sense that the result of the survey is completely misleading.

- the determination of the population
- the sampling method
- sample size and
- how the sample was obtained.

4.4.1 Population of interests

4.4.1.1 Firms vs. projects

The unit of analysis was any project in which a new product was developed and commercialised in a recent period, say five years. So in the exact sense, the population of this survey should be all those new product projects with new products being made available for sale in the last five years in the UK's ICT sector. The reason for the time restriction is very simple. First, the respondents who have the experience of developing a new product may no longer be available if the product was developed a long time ago. Secondly, the respondents may not have a good memory about the NPD process for a relatively long period. Practically, however, it is implausible to find a direct sampling frame for such a population. For example, it might be difficult to obtain a precise description of how many projects were going on even in a single large company without good access. The cost (in the sense of time and money) of obtaining a sampling frame for such a population would be beyond the scope of this research. As a matter of fact, to the knowledge of the author, there have been no previous studies in the NPD literature using such a direct sampling frame. Instead an indirect population was used, that is, the population would be the UK based firms which developed information and communications technology products. This may bring some bias in the interpretation of the results:

- Large firms have large numbers of different projects, while small firms tend to have fewer projects. There might be some danger of over-representing small firms because the numbers of small firms were far greater than that of large ones.

- The choices of products were at the hands of respondents. It was expected that there could be a way for a representative sample for the sake of "newness", but there was no such way to establish a sampling frame based upon this subjective index.

It was therefore necessary to reduce such bias by choosing a proper sampling method which considered both firm size and differences in industry sectors together. The sampling method will be described in the next section.

4.4.1.2 UK's ICT sector

As discussed above, the companies of primary concern in this study were UK-based companies that manufactured ICT-based products, in which there was at least one new product available for sale in the past 5 years. Instead of concentrating on large firms as done in Barczak's study (1995) on the US telecommunications industry, in which she limited the company size to sales turnover larger than $25 million, it was decided to include smaller companies in this study as well. The limit was set to companies with sales turnover larger than £1million. From previous studies (McDougall & Robinson, 1990, Barczak 1995), the ICT sector here refers to companies classified by the US-SIC codes in Table 4.2:

Table 4.2. Information and Communications Technology based companies selected to study

US SIC	Description
SIC 3555:	Printing trades machinery and equipment
SIC 3572:	Typewriters
SIC 3573:	Electronic computing equipment
SIC 3574:	Calculating and accounting machines
SIC 3579:	Office machines, not elsewhere classified
SIC 3613:	Switchgear and switchboard apparatus
SIC 3652:	Phonograph records and precoded magnetic tape
SIC 3661:	Telephone and telegraph apparatus
SIC 3662:	Radio and television transmitting, signalling, and detection equipment and apparatus.

FAME (Financial Analysis Made Easy)[8] uses a new US-SIC code which labels the industry more clearly as shown in Table 4.3. The main difference between the code FAME used and Barczak (1995) used can be seen by a direct comparison of Table 4.2 to Table 4.3:

- Differences in US-SIC 357 computer and office equipment. FAME uses US-SIC 3571 3572 3575 3577 3578 and 3579 as it is shown in Table 4.3 instead of US SIC 3572 3573 3574 3579 as specified in Table 4.2.

- Differences in US-SIC 366 communications equipment. FAME uses US-SIC 3661 3663 and 3669 as it is shown in Table 4.3 instead of US-SIC 3661 3662 as specified in Table 4.2.

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[8] An online CD-ROM comprises the *Jordan Watch Database* of major public and private British companies.

Table 4.3 Information and Communications technology based companies

US SIC	Description
SIC 357:	Computer and office equipment
SIC 3571:	Electronic computers
SIC 3572:	Computer storage devices
SIC 3575:	Computer terminals
SIC 3577:	Computer peripheral equipment, not else where specified
SIC 3578:	Calculating and accounting machines
SIC 3579:	Office machines not elsewhere specified
SIC 366:	Communications equipment
SIC 3661:	Telephone and telegraph apparatus
SIC 3663:	Radio and television broadcasting and communications equipment
SIC 3669:	Communications equipment not elsewhere specified
SIC 3613:	Switchgear and switchboard apparatus
SIC 3652:	Phonograph records and precoded magnetic tape
SIC 3555:	Printing trades machinery and equipment

A summary of companies provided by FAME with classification specified in Table 4.3 is shown in Table 4.4.

Table 4.4 Distribution of major UK-based ICT companies by US-SIC code (FAME)

SIC code	Description	Number of ICT companies		
SIC 357	Computer and office equipment	1531[9]	(1965)[10]	[1204][11]
SIC 3571	Electronic computers	584	(719)	
SIC 3572	Computer storage devices	584	(719)	
SIC 3575	Computer terminals	937	(1209)	
SIC 3577	Computer peripheral equipment, not else where specified	584	(719)	
SIC 3578	Calculating and accounting machines	88		
SIC 3579	Office machines not elsewhere specified	671	(852)	
SIC 366	Communications equipment	1996	(2775)	[1657]
SIC 3661	Telephone and telegraph apparatus	179	(236)	
SIC 3663	Radio and television broadcasting and communications equipment	951	(1248)	
SIC 3669	Communications equipment not elsewhere specified	1117	(1652)	
SIC 3555	Printing trades machinery and equipment	90	(121)	
SIC 3613	Switchgear and switchboard apparatus	214	(284)	
SIC 3652	Phonograph records and precoded magnetic tape	632		
Total		3364	(4542)	[2709]

[9]Sales turn-over larger than £1,000,000 (Latest available year's data)
[10]Number of the companies without the restriction of the minimum £1,000,000 sales turnover
[11]Sales turn over larger than £1,000,000 (From 1st April 1993 to 31 March 1994)

4.4.1.3 Sampling frame

The procedure used in this study to get the sampling frame is shown in Fig. 4.4.

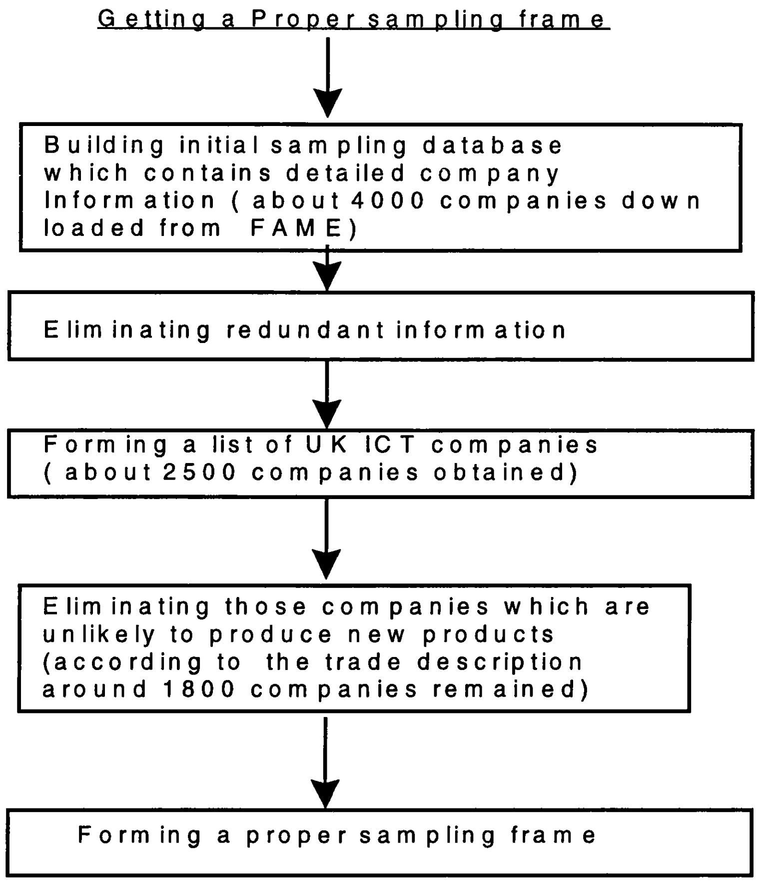

Fig. 4.4 The procedure of getting a 'representative' sampling frame

First, company information was down loaded from FAME according to individual four digit US-SIC code (SIC 3571, 3572, 3575, 3577, 3578, 3579, 3661, 3663, 3669, 3555, 3613, 3652). The information down loaded for each company was as follows:

- *Company Name*
- *Company Type (Public/Private)*
- *Company Status (In business or not)*
- *Address*
- *Phone Number*
- *PostCode*
- *Trade description*

- *US SIC Codes*
- *UK SIC Codes*
- *Consolidated or not*
- *Trading Period*
- *Turnover*
- *UK Turnover*
- *Gross Profit*
- *Profit (Loss) before Interest*
- *Profit (Loss) before Taxation*
- *Profit (Loss) after Taxation*
- *Number of Employees*
- *Fixed Assets*
- *Tangible*
- *Intangible*
- *Total Assets*
- *HOLDING COMPANIES*
- *SUBSIDIARIES*

Secondly, redundant information was compressed. To include every possible company in the sampling frame, company information was retrieved according to individual US-SIC codes. The Boolean operation provided in FAME was not used[12], instead it was done manually. For example, some companies have several US-SIC codes, therefore their information might be downloaded several times. These records should be compressed into one record. After eliminating that redundant information, about 2500 company records were maintained. Using trade descriptions provided by FAME, many of the 2500 companies found did not qualify for the population definition. It was not uncommon that the same company had different names therefore occupied different records. So a further elimination process was employed which yielded 1853 company records that served as the final sampling frame.

[12] An obvious logical error was detected when the Boolean operation was used in FAME at the time the research was conducted.

4.4.1.4 Concentration rate: large companies and small companies

These 1853 companies were in descending order according to their latest annual sales turnover[13]. It is shown in Fig. 4.5 that the first 170 companies contributed about 80 percent of the total sales turnover. The annual sales turnover of each of these companies was greater than £ 50 million. Companies in this group were labelled as large companies. Another 10% of the total sales turnover was counted approximately by 440 companies with annual sales turnover in between £10 million to £50 million. Companies in this group were labelled as medium sized companies. The remaining 10% total sales turnover was expressed by 1243 small companies with sales turnover ranging from £1million to £10 million. Companies in this group were labelled as small companies.

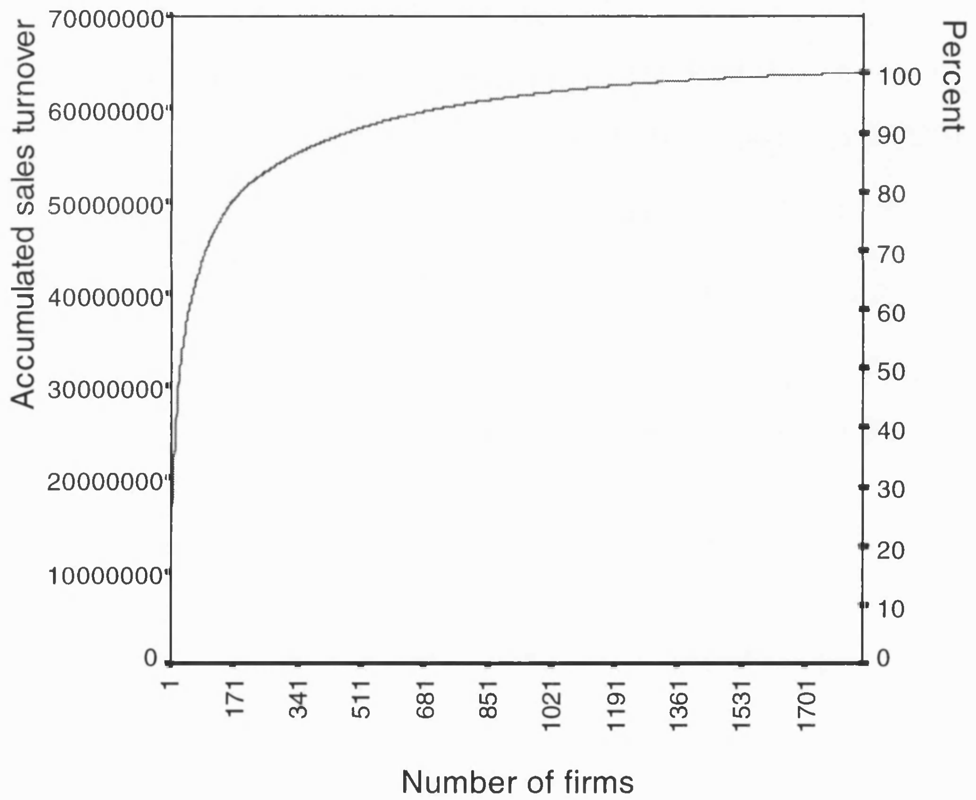

Fig. 4.5 Concentration curve of the sales turnover (£, 000)

[13] The reason sales turnover instead of employee number was used is limited by FAME. Although employee number was provided in FAME and the information was downloaded as well, it was found that there were too many missing values in this index.

4.4.1.5 Three sectors

Intuitively, the ICT sector can be divided into two sub-sectors: computer industry and telecommunications industry. However, with the integration of computer technology and telecommunication technology, more and more firms manufacture products which belong to both industries. Yet there are still distinctions between these two industries. In reflecting the common points as well as distinctions of both sectors, companies in ICT sector were classified into three sub-sectors:

- Sector A: computer and office equipment sector but not the communications equipment, US SIC Code 3555 3571 3575 3578 3579 3652.
- Sector B: the communications equipment but not computer and office equipment, US SIC code 3661 3663 3669 3613.
- Sector C: doing both the communications equipment and computer and office equipment.

Table 4.5 shows the population distribution according to firm size and sector classification.

Table 4.5 Population distribution

Number of companies in the sampling frame	**Sector A** (computer and office equipment sector but not the communications equipment US SIC Code 3555 3571 3575 3578 3579 3652)	**Sector B** (the communications equipment but not computer and office equipment US SIC code 3661 3663 3669 3613)	**Sector C** (doing both the communications equipment and computer and office equipment)	**Total**
Large firms (Last year sales turnover greater than £50 m)	85 *(50%)*	42 *(24.71%)*	43 *(25.29%)*	170 *(9.17%)*
Medium firms (10 to 50 m)	232 *(52.73%)*	87 *(19.77%)*	121 *(27.5%)*	440 *(23.75%)*
Small firms (<=10m)	650 *(52.29%)*	263 *(21.16%)*	330 *(26.55%)*	1243 *(67.08%)*
Total	967 *(52.19%)*	392 *(21.15%)*	494 *(26.66%)*	1853

The figures at the last column of Table 4.5 showed the number of firms in each category according to the firm size and the percentage of firms in that category occupied in the whole population. For example the number in the first cell in the last column showed that the number of large firms is 170 which accounted for 9.17% of the total population of 1853. Similarly, the last row of the Table 4.5 showed the total number of firms according to industrial sectors and the percentage it occupied in the total population. For example, the first category of last row shows the total number of firms in Sector A was 967 which accounted for 52.19% of the total population of 1853 firms. The figure in brackets is the row percentage of each stratum. For example the first cell in Table 4.5 there were 85 large firms in Sector A accounting for 50% of the total large firms (170). Unless specifically explained, tables appeared later in this chapter (Table 4.6, 4.7, 4.9 and 4.11) will follow the same pattern as Table 4.5.

4.4.2 Sample size estimation

The determination of sample size was difficult in this case because there was no prior knowledge about the population means and deviation. An approximate formula (Kalton,1983) was used to estimate sample size in this case:

$$n=Z^2P(1-P)/E^2$$

Where Z= level of confidence expressed in standard errors

P= population percentage (companies that have developed at least one new product in recent five years)

E= acceptable amount of sampling error

Let Z=1.96 (95% confidential level) P=0.50 (Largest value of P(1-P)) E=0.10

Therefore $n=1.96^2*0.5*(1-0.5)/0.1^2=96$

Previous studies in the ICT sector gave an average return rate of 36% (Barczak 1995) to 38% (Littler et al 1994). This study mainly focuses on in-depth 'process' perspectives which would deter many respondents who have a general knowledge about new product development in their organisation but who have not participated in the whole process himself/herself (or perhaps their organisation participates only in part of the NPD activity). It would therefore be dangerous to assume the response rate could be as high as that[14]. The estimated response rate used in this study was based on previous studies in NPD area with similar level of questionnaire complexity (e.g. Ali 1995). Suppose the response rate is 15% (without pre-telephone investigation) or 25% (After pre- telephone interview was conducted) respectively, the pre-set sample size should be at least n'=96/0.15=640 or n"=96/0.25=384. According to previous research (Ali 1995), the response rate for the telephone contact could be above 50%. Suppose the response rate of telephone survey work is 50%, the sample size should be n=384/50%=**768**.

Considering that the population size N is finite, the finite population correction factor was used to re-valuate the amount of sampling error E (Churchill 1995). This yielded a smaller value of E=0.077. It should be pointed out that the above formula is based on simple random sampling. The pre-set sample size was sufficient for the stratified sampling as well, because the

[14] The final results showed that many respondents did try to complete the questionnaire but they were not being able to do so because they lacked the knowledge especially for the two relatively complicated items about the linearity construct and the parallel level construct.

gain in precision obtained in the stratified sampling was larger than simple random sampling (See Section 4.4.3.2 for a calculation of the gains of precision).

4.4.3 Sampling method

As described above, the population of this research is UK-based ICT companies with sales turnover larger than £1 million which have made at least one new product available for sale in the last five years. Intuitively it might be worth using stratified sampling by dividing the population into large and small companies. Because in this industry the first 170 companies counted for eighty percent of the total sales turn-over, it might be right to grasp the "vital few", given such a concentration rate. Another factor which should be taken into consideration is that the NPD process for the computer industry and for the communications industry might be different. This also leads to favour the choice of stratified sampling.

4.4.3.1 Stratified sampling

Of the stratified sampling, there were three methods to choose, that is, the uniform sampling method, the proportionate method and the optimum allocation method.

Uniform sampling is a method that divides sample size equally among different strata. In this case, uniform sampling on the dimension of sample size yielded Table 4.6.

Table 4.6 Sampling distribution: Disproportionate method/Uniform sampling (n=768)

Number of companies in the sample (Estimation of sample size in each category)	**Sector A** (computer and office equipment sector but not the communications equipment US SIC Code 3571 3555 3575 3578 3579 3652)	**Sector B** (the communications equipment but not computer and office equipment US SIC code 3661 3663 3669 3613)	**Sector C** (doing both the communications equipment and computer and office equipment)	**Total**
Large firms (Last year sales turnover greater than £50 m)	85 (50%)	42 (24.71%)	43 (25.29%)	170 *(22.13%)*
Medium firms (£10 to 50 m)	158 *(52.73%)*	59 *(19.77%)*	82 *(27.5%)*	299 *(38.93%)*
Small firms (<=£10m)	156 *(52.29%)*	63 *(21.16%)*	80*(26.55%)*	299 *(38.93%)*
Total	399 *(51.95%)*	164 *(21.36%)*	205 *(26.69%)*	768

In Table 4.6, the three categories (large firm, medium firm, and small firm) were assigned equal numbers i.e. 768/3=256 for each category. However because there were only 170 large firms, the first category could only be 170. The remaining 598 (768-170) were divided evenly among the other two categories. In each row, the number was assigned proportionally according to the percentage of each stratum in the population.

In proportionate samples, the sampling fraction in each stratum is made equal to the sampling fraction for the population as a whole, that is, it represents all strata among the sample cases in the ratio of the strata in the population. The result for proportionate sampling is shown in Table 4.7. As for the optimum allocation method, it involves the deliberate use of widely different sampling rates for various strata. According to Kish (1965),

> *"the designation optimum allocation refers to the aim of assigning sampling rates to the strata in such a way as to achieve the least variance for the overall means per unit of cost.(p92)".*

Table 4.7 Sampling distribution: proportionate method (n=768)

Number of companies in the sampling frame	**Sector A** (computer and office equipment sector but not the communications equipment US SIC Code 3555 3571 3575 3578 3579 3652)	**Sector B** (the communications equipment but not computer and office equipment US SIC code 3661 3663 3669 3613)	**Sector C** (doing both the communications equipment and computer and office equipment)	**Total**
Large firms (Last year sales turnover greater than £50 m)	35 *(50%)*	18 *(24.71%)*	18 *(25.29%)*	71 *(9.17%)*
Medium firms (£10 to 50 m)	96 *(52.73%)*	36 *(19.77%)*	50 *(27.5%)*	182 *(23.75%)*
Small firms (<=£10m)	269 *(52.29%)*	109 *(21.16%)*	137 *(26.55%)*	515 *(67.08%)*
Total	400 *(52.08%)*	163 *(21.22%)*	205 *(26.69%)*	768

The calculation process for the optimum allocation is shown in Table 4.8. The fraction of each stratum is equal to the ratio of N*S where N is the number of population in each stratum and S is the standard deviation of each stratum on sales-turnover.

Table 4.8 Calculation of the optimum allocation by firm size (sales turnover) (n=768)

Stratum	**Population** N	**Standard Deviation** S	**N*S**	**Sample size**
Large firm	170	575582.26	97848984	170[15]
Medium firm	440	9417.36	4115078	348
Small firm	1243	2350.14	2927451	250
Total	1853	192745.9	-------	768

[15]The proportion from N*S yield 34:1.4:1 for large:medium:small. The estimated sample size for large firm stratum exceed 170.

Because the fraction for the first category (large firm) is so large, all the firms in the first category were included. The second category and the third category yield a 1.4:1. The remaining 598 (768-170) were divided among the last two categories according to this proportion 348:250=1.4:1. The sample was then divided proportionally along different industrial sectors according to the ratio of each stratum in the population. The result is shown in Table 4.9.

Table 4.9 Sampling distribution:The optimum allocation method (n=768)

Number of companies in the sample (Estimation of sample size in each category)	**Sector A** (computer and office equipment sector but not the communications equipment US SIC Code 3571 3555 3575 3578 3579 3652)	**Sector B** (the communications equipment but not computer and office equipment US SIC code 3661 3663 3669 3613)	**Sector C** (doing both the communications equipment and computer and office equipment)	Total
Large firms (Last year sales turnover greater than £50 m)	85	42	43	170 *(22.13%)*
Medium firms (£10 to 50 m)	183 *(52.73%)*	69 *(19.77%)*	96 *(27.5%)*	348 *(45.31%)*
Small firms (<=£10m)	131 *(52.29%)*	53 *(21.16%)*	66*(26.55%)*	250 *(32.55%)*
Total	399 *(51.95%)*	164 *(21.36%)*	205 *(26.69%)*	768

4.4.3.2 Gains of precision

Cochran (1977) suggested

"The ideal variate for stratification is the value of y itself--the quantity to be measured in the survey. .... In practice, of course, we cannot stratify by the value of y. But some important applications come close to this situation, and therefore give large gains in precision, by satisfying the following three conditions.

1. *The population is composed of institutions varying widely in size.*
2. *The principle variables to be measured are closely related to the sizes of the institutions.*
3. *A good measure of size is available for setting up the strata. (p101)*

.....

As regards proportional versus optimum stratification, there are two situations in which optimum stratification wins handsomely. The first is the case, already discussed, in which the population consists of large and small institutions, stratified by some measure of size. The variances are usually much greater for the large institutions than for the small, making proportional stratification inefficient. ... (p103)"

As to this research, it was easy to identify that the first and the third conditions mentioned above were satisfied. The ICT companies in the sampling frame varied widely in size from sales turnover several millions to tens thousands millions pounds (See Table 4.8 for a comparison of the standard deviations in each category). The sales turnover index was also used in setting up strata as well as analysing the variance among different strata. As for the second condition, it might need some judgement. The principal variables to be measured were product newness, NPD process variables and performance variables of individual product. Suppose only two individual firms were compared, one very large, one very small. It was reasonable to assume that the number of NPD projects for the large firm is far greater than that of the smaller company. Other things being equal, it was therefore safe to say that the NPD process may be more variable in this large firm than in the small firm. According to Stuart (1984) "*...it pays to over-sample the more variable strata in the population (P40)*" and it is also important to notice that:

"The penalty of over-sampling the wrong (less variable) stratum has been very severe in this case, since we are now estimating much less precisely than we did with no stratification at all. It is quite clear that stratification with variable sampling fractions is a double-edged weapon, which may turn against us if (through ignorance or inefficiency) we concentrate our sample in the wrong part of the field. (p41)"

A lot of empirical studies have shown that there tends to exist a close relationship between firm size and the innovativeness of the company (Damanpour,1992, Ettlie and Rubenstein 1987). While some research presented a positive relationship (Blau and Mckinley 1979; Dewar and Dutton 1986; Young, Hougland and Shepard 1981), others presented a negative one (Hage,1980), and some earlier studies presented non-significant relationships (Aiken, Bacharach and French 1980), depending on different measures of innovativeness they used. Damanpour's (1992) meta-analysis for 36 estimates of the relationship between size of organization and innovation indicated a positive and statistically significant relationship between size and innovation. Giving these considerations, it was assumed that the second condition of Cochran's assumption was satisfied in this case.

Having established this relationship, it is beneficial to go on to examine further the exact gains of precision of these methods according to the formula provided by Kish (1965)4.6b.

The ratio of the total simple random sampling variance remaining in a proportionate sample is:

$$\frac{Var(\bar{y}_{prop})}{Var(\bar{y}_0)} \doteq 1 - \frac{\sum W_h (Y_h - \bar{Y})^2}{S^2}$$

The ratio of the total simple random sampling variance remaining in an optimum allocation sample is:

$$\frac{Var(\bar{y}_{opt})}{Var(\bar{y}_0)} \doteq 1 - \frac{\sum W_h (\bar{Y}_h - \bar{Y})^2}{S^2} - \frac{\sum W_h (S_h - \bar{S})^2}{S^2}$$

Where $Var(\bar{y}_{prop})$: variance of proportionate sampling

$Var(\bar{y}_{opt})$: Variance of optimum sampling

$Var(\bar{y}_0)$: Variance of simple random sampling

S: Standard deviation of the population

$\bar{S}$: Average standard deviation of population

$\bar{Y}$: Mean of the population

$\bar{Y}_h$: Population mean in hth stratum

W_h : relative population size of stratum h

S_h : standard deviation of the population in hth stratum

The calculation procedure is shown in Table 4.10. From Table 4.10, two figures are obtained:

$$A_1 = \frac{\sum W_h (S_h - \bar{S})^2}{S^2} = 0.732221$$

$$A_2 = \frac{\sum W_h (\bar{Y}_h - \bar{Y})^2}{S^2} = 0.185414$$

Therefore the relative gain due to proportionate sampling is expanded as the portion of the simple random sampling variance it eliminates, that is,

$$\text{Gain(prop. vs. srs)} = 1 - \frac{Var(\bar{y}_{prop})}{Var(\bar{y}_0)} \doteq \frac{\sum W_h (Y_h - \bar{Y})^2}{S^2} = 0.185414 = 18.5414\%$$

Similarly the relative gain due to optimum sampling can be calculated as follows:

$$\text{Gain(opt. vs. srs)} = 1 - \frac{Var(\bar{y}_{opt})}{Var(\bar{y}_0)} \doteq \frac{\sum W_h (\bar{Y}_h - \bar{Y})^2}{S^2} + \frac{\sum W_h (S_h - \bar{S})^2}{S^2} = 0.185414 + 0.73221 = 0.91765 = 91.765\%$$

Hence the relative gain of optimum sampling versus proportionate sampling is:

$$\text{Gain(opt. vs. prop.)} = 1 - \frac{Var(\bar{y}_{opt})}{Var(\bar{y}_{prop.})} = 1 - \frac{Var(\bar{y}_{opt})}{Var(\bar{y}_0)} / \frac{Var(\bar{y}_{prop})}{Var(\bar{y}_0)} = 1-(1-0.91765)/(1-0.185414) = 0.8989 = 89.89\%$$

The calculation confirmed that it is worth using the optimum allocation procedure in this case.

Table 4.10 Calculation of gains of precision[16]

Stratum	W_h	$\bar{Y}_h - \bar{Y}$	S_h	$W_h\ S_h$	$S_h - \bar{S}$	$W_h (S_h - \bar{S})^2$	$W_h (\bar{Y}_h - \bar{Y})^2$
Large firms	0.0917	260296.5	575582.26	52780.89	519000.3	24700434660	6213064458
Medium firms	0.2375	-14153.1	9352.45	2221.21	-47229.5	529773254.3	47573883.6
Small firms	0.6708	-30589.7	2355.15	1579.84	-54226.8	1972517038	627686283
$\sum$			$\bar{s}$ = 56581.93			27202724952	6888324624
	S= 192745.9 (From Table 4.8)				S^2= 37150970402		

[16]The calculation of precision is based on Kish (1965) 4.6b, under the assumptions of Cochran (1977) 5.7 P101.

4.4.4 Obtaining a sample

Now that in section 4.4.3, optimum allocation method was chosen, the next step is to get the sample from the sampling frame. The procedure used in this study to get a sample is shown in Fig. 4.5.

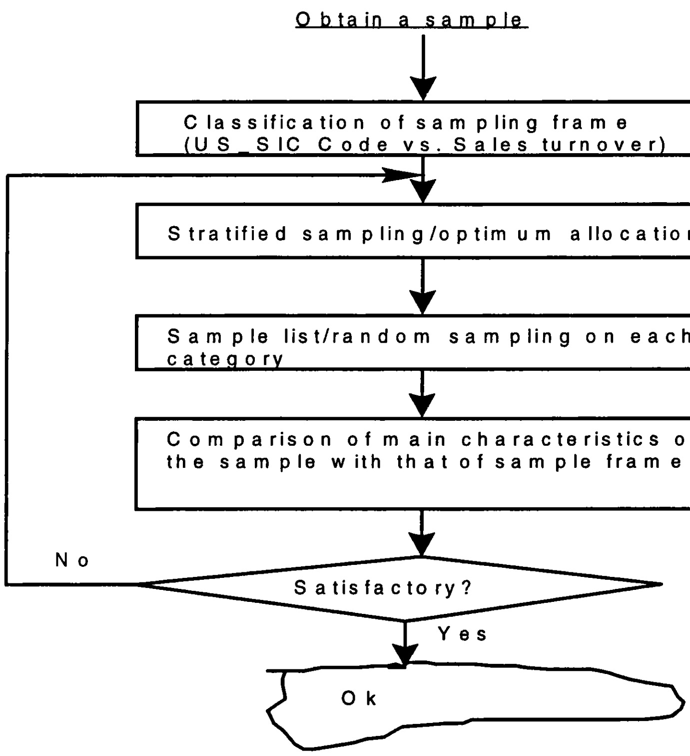

Fig. 4.5 The procedure of sampling

The stratified sample was based on the optimum allocation methods discussed in the above section. According to Table 4.9, the population was divided into nine strata. The first three strata (in the second row of Table 4.9) were equal to the population, therefore it was unnecessary to do any sampling for these three strata. As for the remaining six strata, simple random sampling was conducted on each of them individually.

In summary, since it was difficult to deal with real population of this research directly, an indirect approach on a population of companies in the UK's ICT sector was developed to get an appropriate sample for this study. Considering both company size and differences in industrial sectors, stratified sampling techniques were used. Among various stratified sampling methods available, the optimum allocation procedure was preferred, which was believed could gain a higher degree of precision than other stratified sampling methods. The sample obtained in this section laid the foundation of further data collection work, which will be described in the next section.

4.5 DATA COLLECTION

Data collection in this study as a whole procedure can be divided into four steps:

1. Obtaining a proper sampling frame: this marked the beginning of the primary data collection and has been described in the last section.
2. Obtaining a sample: a good sample laid the foundation of the data collection. This step was also described in the last section. In this section the other two steps will be discussed:
3. Telephone survey work. Before the postal survey started, telephone survey work was conducted. The purpose of the telephone survey work was not solely for pre-notification. Its main tasks were to find the right person in the right company so that to whom the postal questionnaire can be posted. Therefore this turned out to be a very important or crucial stage of the research.
4. Postal survey. Postal survey is the "real" attempt to collect the information required by this study. A key concern at this stage is the non-response or the response rate.

Fig. 4.6 shows the whole procedure of data collection. Whereas the first two steps of data collection concerning sampling issues have been described in section 4.4, in this section the discussion will focus on the other two steps of the data collection, issues concerning the telephone survey work and the postal survey, although response and non-response analysis will be carried out later in the next chapter.

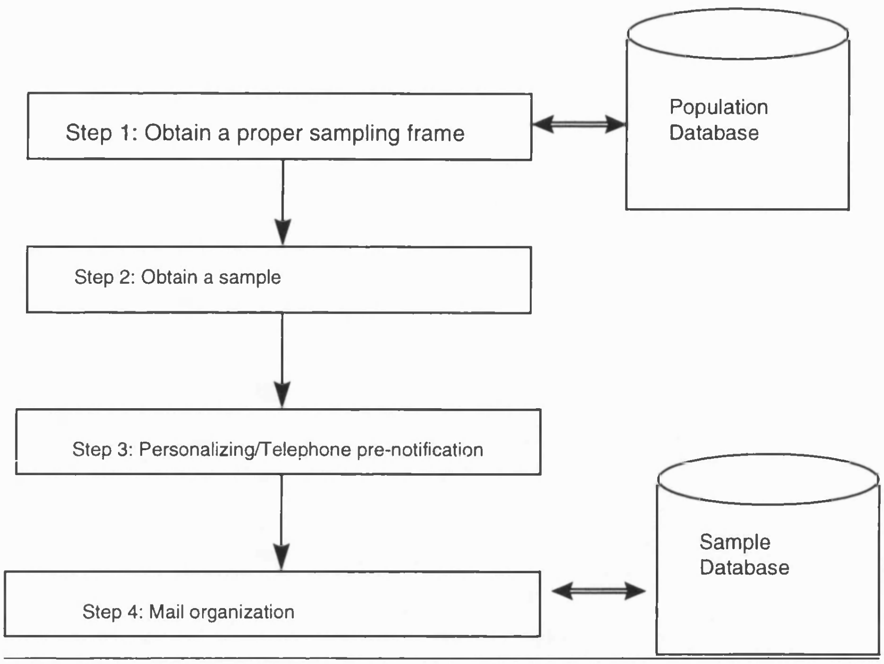

Fig. 4.6 Steps in data collection

4.5.1 Telephone survey work

After a proper sample was obtained by the optimum allocation method, telephone survey work was carried out. As it was suggested earlier, the sampling frame used was not a direct reflection from the population targeted. Hence there is a need to find out the right people, in the right company for the questionnaire. The telephone survey work served this purpose. First, it was designed to find out if firms in the sample were really qualified for the survey, that is, did they develop new ICT products in the past five years although from the trade description obtained from FAME it has been confirmed initially that those companies did manufacture ICT products. That is, the telephone survey work served the purpose of building a more accurate sampling frame.

The second purpose of the telephone survey work was to looking for the person who had a general familiarity with NPD activities in the firm. This was very important because the questionnaire should be filled out by a person who has expertise and experience in developing a new product. For example, he (or she) must nominate a new product he had worked on.

Understandably, people who have an in-depth knowledge and experience of new product development activities would not be a majority in the firm and they are usually highly occupied.

Therefore the third purpose of the survey was to pre-notify potential respondents the coming of the questionnaire and to persuade them to participate in the survey. The telephone survey work proved to be very useful to achieve these purposes. It not only increased the response rate, but also was helpful in increasing the quality of each questionnaire filled in. Indeed, it is not that easy to find the right person in an organization. A vice president in a large company, who is responsible for new product development, said in an interview after the survey, "The event itself is a great achievement that you found me in this organization". Despite many studies in the NPD area using prior telephone notification (e.g. Ali 1994), the procedure established here for telephone survey work has not been reported by other authors. Despite its quantitative orientation, one of reasons for using such a relatively formal process is the emphasis of the importance of the telephone survey work which is actually critical for the success of the survey. The amount of workload encountered also demanded the use of a relatively formal process to guarantee the same criteria were kept to by different people. In addition, lessons from other researchers(Barczak 1995) also suggested the necessity of using a well-documented process.

The procedure used for the telephone survey is shown in Fig. 4.7.

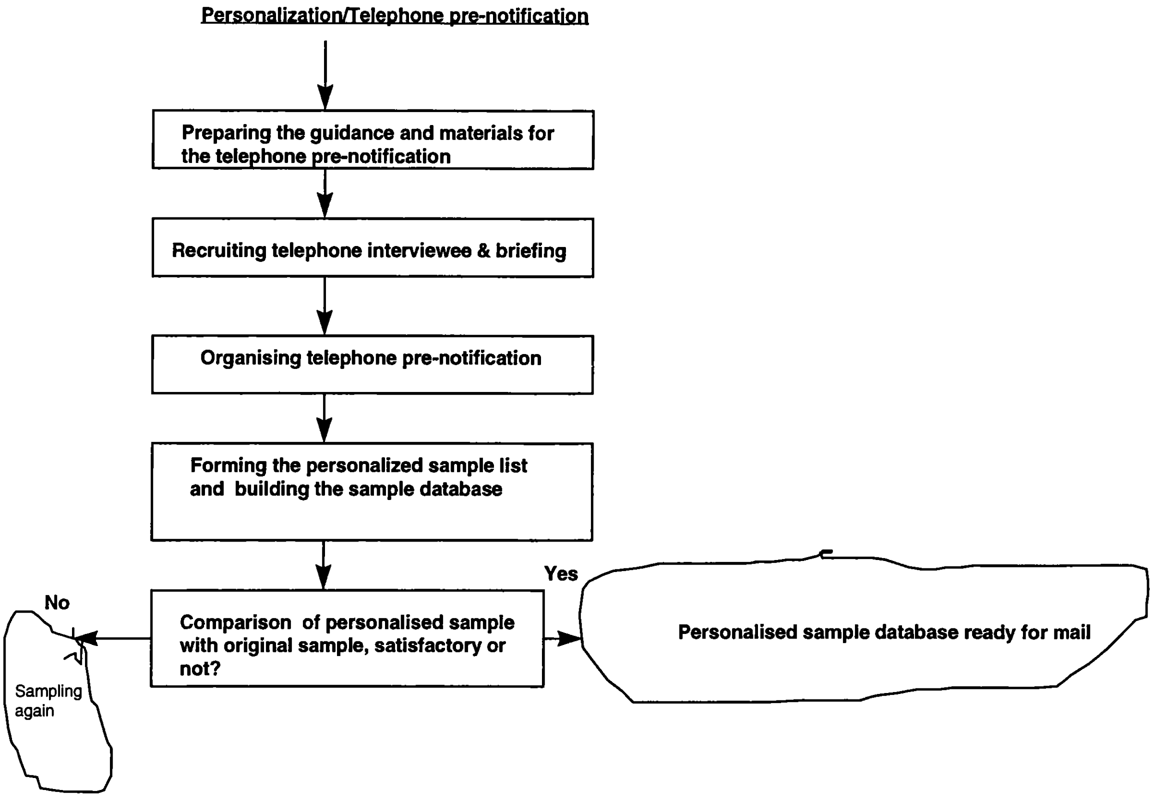

Fig. 4.7 Procedure of the telephone survey work

Before the formal telephone survey work began, the author spent three months exploring various ways to contact British companies, working out proper strategies for different kinds of firms. Based on this experience, a one page telephone survey questionnaire was designed and then was tested repeatedly for more than 10 phone calls. The survey questionnaire was firm specific. Each firm had a different questionnaire. Appendix IV shows an example of the survey questionnaire for IBM. Each survey questionnaire was divided into two sections.

The first section provided relevant information of the company and was to be filled out by the interviewer during the process of the phone call. In this section, the name of the company, the telephone number of the company, and the address information of the company was provided. Some information was repeated twice for the convenience of the survey work. The interviewers were requested to find out if the company had developed a new product and who was the best person to fill out the questionnaire. The interviewers were also asked to check if the company information (e. g. company name, address) provided in advance was correct.

The second section is the summary section. It was requested to be filled in after the phone call: the summary section. The interviewers were asked to answer three questions:

First, *to what extent do you think the respondent would complete and return the questionnaire?* The answer would be

Definitely not/ Less likely to response/Possible/Highly possible/Definitely will. The judgement of the interviewers was used for two purposes: a prediction of response rate and differentiation between respondents. The result of this prediction was used to judge if the response obtained from telephone survey work was sufficient for the postal survey, e.g. if it was necessary to add more companies to the sample before the postal survey began. The result of this differentiation was used to form efficient strategies for conducting the postal survey.

The second question was to note down the number of phone calls the interviewer made. This was relevant to the postal survey carried out later in which there was also a telephone support stage. The third question required the interviewers to note down his (her) brief comments and suggestions for further contact. This also proved to be very useful in identifying important respondents who had a particular interest in this research.

The telephone survey work was carried out by three people, two of them are native British both with two years tele-marketing experience, the other was the author. Before the telephone survey work began, an informal briefing took place. A detailed written guideline for the work was prepared for each interviewer. Based on the experience of phoning more than two hundred companies, the author explained to them how to phone properly and showed them via phoning one or two companies. The guiding materials for the telephone survey work are shown in Appendix V.

For the purpose of raising the response rate and enhancing the quality control , the interviewers were compensated via basic salaries plus a bonus. The basic salary was counted according to working hours and a relatively high bonus was awarded according to the number of postal questionnaires returned. The use of a bonus motivation greatly stimulated the interviewers interests and productivity. The telephone survey lasted about three weeks (including typing in the survey message). 501 companies were identified as suitable for this research and personalised addresses were obtained. The result of the telephone survey work is shown in Table 4.11.

Table 4.11 Sampling distribution: the result of telephone pre-notification (n=501)

Number of companies in the sample (Estimation of sample size in each category)	**Sector A** (computer and office equipment sector but not the communications equipment US SIC Code 3571 3555 3575 3578 3579 3652)	**Sector B** (the communications equipment but not computer and office equipment US SIC code 3661 3663 3669 3613)	**Sector C** (doing both the communications equipment and computer and office equipment)	**Total**
Large firms (Last year sales turnover greater than £50 m)	51 *(52.04%)*	21 *(21.42%)*	26 *(26.53%)*	98 *(19.56%)*
Medium firms (£10 to 50 m)	121 *(50.20%)*	48 *(19.92%)*	72 *(29.88%)*	*241 (48.10%)*
Small firms (<=£10m)	78 *(48.14%)*	35 *(21.60%)*	49 *(30.25%)*	162 *(32.3%)*
Total	250 *(49.90%)*	104 *(20.75%)*	147 *(29.34%)*	501

A comparison of the result with original sample is shown in Table 4.12.

Table 4.12 Representativeness: the result of telephone prenotification versus the optimum allocation sample(n=501)

Number of companies in the sample (Estimation of sample size in each category)	**Sector A** (computer and office equipment sector but not the communications equipment US SIC Code 3571 3555 3575 3578 3579 3652)	**Sector B** (the communications equipment but not computer and office equipment US SIC code 3661 3663 3669 3613)	**Sector C** (doing both the communications equipment and computer and office equipment)	**Total**
Large firms (Last year sales turnover greater than £50 m)	51/85 *(60%)*	21/42 *(50%)*	26/43 *(60.46%)*	98/170 *(57.64%)*
Medium firms (£10 to 50 m)	121/183 *(66.12%)*	48/69 *(69.56%)*	72/96 *(75%)*	*241/348 (69.25%)*
Small firms (<=£10m)	78/131 *(59.54%)*	35/53 *(66.03%)*	49/66 *(74.24%)*	162/250 *(64.8%)*
Total	250/399 *(62.65%)*	104/164 *(63.41%)*	147/205 *(71.70%)*	501/768 *(65.23%)*

It can be seen from Table 4.12 that the over-all response rate of the telephone survey work was 65.22% and there is no specific stratum with response rate lower than 50%. A further analysis for the response of telephone survey work will be presented in the next chapter, whereas this chapter is limited on the "procedure" perspective of the research.

According to the interviewer's subjective judgement a prediction of the response rate for the mail survey is shown in Table 4.13. It was, of course, of great interest to know what could be achieved finally in the postal survey.

Table 4.13 Prediction of the response rate for the mail survey (n=501)

Judgement	Result from the telephone work	Optimistic expectation (response rate)	Pessimistic expectation (response rate)	Average (response rate)
Definitely will	23	17 (0.75)	11 (0.50)	14 (0.60)
Highly possible	149	74 (0.50)	37 (0.25)	55 (0.37)
Possible	248	62 (0.25)	31 (0.125)	46 (0.19)
Less likely to response	81	10 (0.125)	5 (0.06)	7 (0.09)
Total	501	163 (32.53%)	84 (16.76%)	122 (24.35%)

4.5.2 Postal survey: the procedure

It goes without saying that one of the major concerns facing any postal survey is the response rate. With the wide spread use of the mail survey, it is more and more difficult to get a high response rate, while a low response rate increases the possibility of sampling bias. Therefore a careful design of the postal survey procedure was required. It was helpful to notice Dillman's work in the late seventies. Based on social economics theory, Dillman (1978) proposed that postal survey is an interactive procedure between researchers and respondents, the response rate of which depends on rewards, costs, and trust established in the procedure. According to his theory, in order to increase the response rate, researchers have to consider not only the direct interests of the respondent but also the social appeal, and psychological reaction of the respondent. Dillman then proposed a comprehensive approach for mail survey design known as the Total Design Method (TDM). TDM is designed for a general survey approach without specific consideration on different populations. Walker, Kirchmann, and Conant (1987) clarified the application of TDM in the industrial settings via a cost and benefit analysis based on Dillman's principle.

Although TDM is relatively exhaustive and covers all facets of questionnaire design and implementation, a disadvantage is that the approach Dillman designed for mail survey used *Post Office* as the only means. There is now more and more evidence showing that the combination of mail approach and telephone support increases response rate, which is true especially in the case of industrial marketing studies. With the decrease of telephone costs, using postal means only in the mail survey will no longer be cost effective. Indeed, a meta-analysis of the effect of industrial pre-notification by Haggett and Mitchell (1994) concluded that telephone pre-notification is more effective than letters or post cards. Besides, progress in computer technology makes the design of questionnaires more flexible. For example, the use of database technology, the design of company specific questionnaires, was not so common some twenty years ago if indeed it was possible at all.

Like many other surveys, the survey conducted in this study was also limited by funding and it was also restricted by time limit. In order to increase the response rate, an analysis to maximize the effect of factors that would stimulate response rate and minimize the hindering effect of response was carried out. The approach used here was then called constricted industrial mail survey (CIMS). Appendix VI gives a further explanation of the concept.

Based on these considerations, the CIMS approach was designed into four steps as shown in Fig. 4.8. A distinct feature of the CIMS procedure is that it addresses formality in every step of the process. For example, all of the questionnaires in the first step were mailed out at the same time in the same manner, yet all of the covering letters were personalized. All of the follow up letters were also personalised and launched exactly two weeks after the launch of the questionnaires. In addition, the telephone support was managed in the same way as the telephone survey work described earlier of this section. Four weeks after mailing out the questionnaire, that is, two weeks after the first follow up letters, the telephone support stage began.

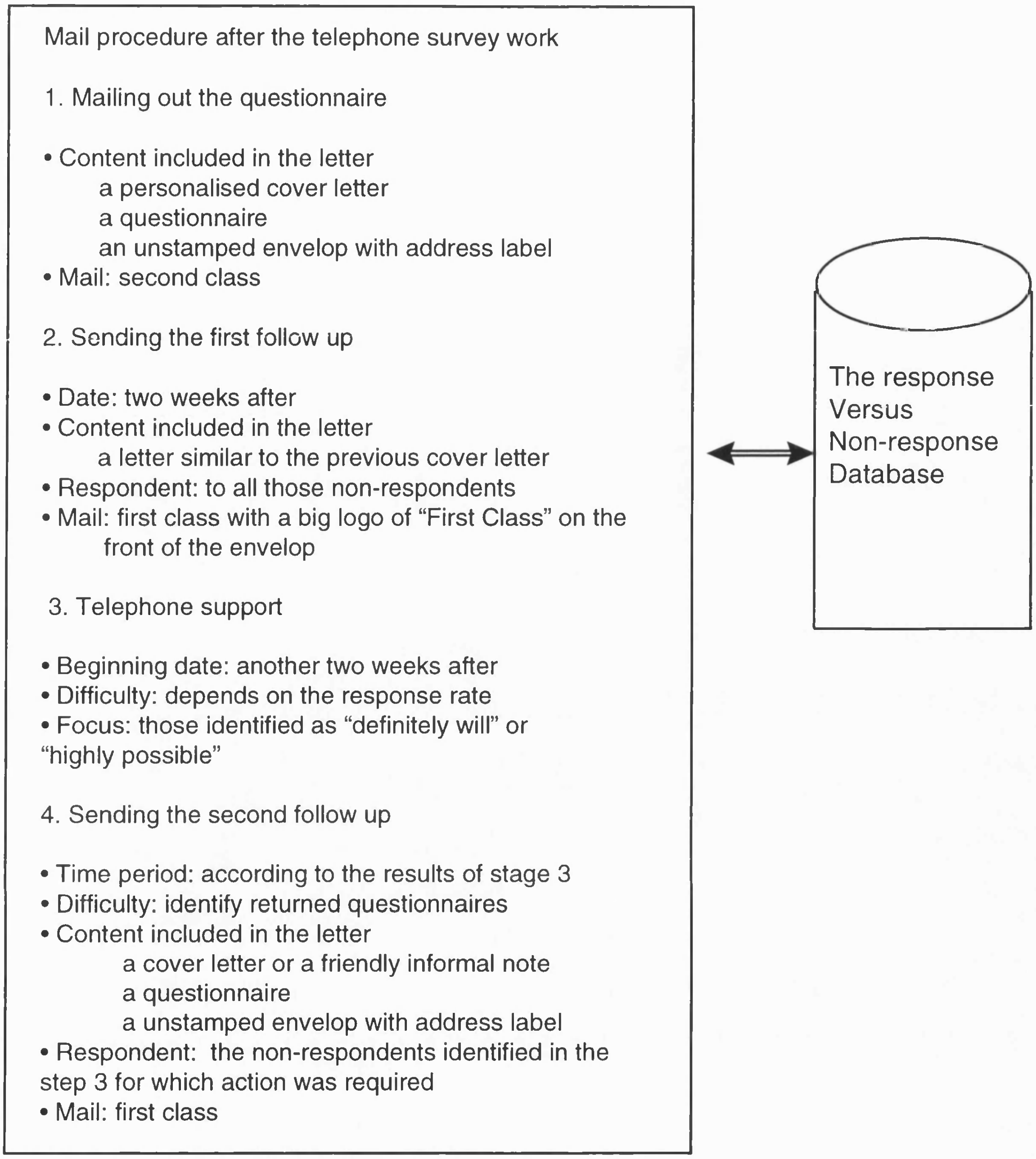

Fig. 4.8 The postal survey procedure

During this process the response and non-response were closely monitored. The response and non-response information were updated daily on a monitoring database. So the target of telephone support was focused on those who had not returned the questionnaire. The first purpose of the telephone support work was to find out why those people had not returned questionnaires as expected so that evidence for response and non-response analysis could be accumulated. The second purpose of the telephone support was, of course, to persuade those non-respondents to complete and return the questionnaire as soon as possible. In order to achieve this, a simple telephone support questionnaire was designed. Again, the questionnaire was company specific. Information about the company identified in the previous stage (e.g. name of the respondent, his/her position in the company, company address) were presented in the questionnaire so that the interviewers had a clear idea about the company and the respondent he/she was going to talk to. An example of the questionnaire for Digital Equipment Scotland Limited is attached in Appendix VII.

This procedure is a modification of Dillman's TDM approach. The main differences between this procedure and the TDM Dillman advocated are as follows:

• Walker, Kirchmann, and Conant (1987)'s analysis of TDM on industrial marketing studies was combined into the CIMS mailing procedure.

• Telephone supports before and during postal survey processes were used. And most importantly, the information obtained in the telephone survey work was used to filter out those possible non-respondents to minimize the cost.

• Certified secondary follow-up was not used in CIMS for the sake of reducing cost. To reduce cost, the questionnaires were mailed out using second class stamp instead of the first class mail. And a self-addressed envelope was enclosed with the questionnaire without a pre-paid first class stamp. Table 4.14 highlights several key features which differentiate CIMS from the procedure recommended by Dillman (1978).

Table 4.14 Differences between TDM and CIMS

Key features	TDM	CIS
Questionnaire stamp	First class	Second Class
Enclosed envelop	Stamped	Not stamped
Timing of first follow up	One week	Two weeks
Telephone support	No	Yes
Certified follow up	Yes	No
Differentiation of respondents	No	Yes
Monitoring of the response	No	Yes

In summary, this section highlighted a unique data collection procedure for structured mail survey, which was developed from the principle of Dillman's TDM and later work of Walker et al (1987) on the modifications of TDM. It is believed that with the development of computer technology, the process used in mail survey will be more and more flexible than twenty years ago when TDM was proposed. Before concluding the description of the procedure of primary data collection, the procedure used for post survey interviews will be introduced in the next section.

4.6 THE INTERVIEWS

Post survey interviews were designed to get a better understanding of the research findings. They were carried out in four steps on an evolutionary basis. First, respondents were contacted to see if they were willing to be interviewed. 501 respondents were contacted and 68 of them agreed to be interviewed. This was done along with the postal survey. Secondly, a brief report of the initial research findings was sent to the respondents interested. Thirdly, a telephone contact was made to set up the interview date and time. Fourthly, a semi-structured interview was conducted. The interview process was evolutionary in the sense that the procedure was repeated several times. Each time two respondents were contacted. The interview questions changed each time on the basis of previous interviews. Because there was a relatively large pool of respondents who agreed to be interviewed, it was therefore possible to choose those cases which were with or against the theme which emerged in data analyses of the postal survey.

The interview process was semi-structured in the sense that all the questions asked during the interview process were open ended. All of these questions were asked around two themes. One of the two themes was to compare the NPD process of a particular product the respondent had developed to the results of the data analysis. The other theme was to explore the respondent's perceptions of the research findings and potential managerial implications of this research. Both themes were built on a structured sheet shown in Table 4.15.

Table 4.15 The question sheet used in the interview

	NPD process				
	Linearity	Parallel level	Formality	Marketing	R&D
Newness to company	Research findings Why?				
Newness to market					
Newness to technology					

As is shown in Table 4.15, the question in each particular cell was focused on one perspective of product newness with one particular NPD process variable. The questions were typically:

- Why did you develop this new product that way?
- Did you develop other new products in the same way?
- What do you think the common theme emerged in the research findings compared to the way things are done in your firm?

It is not difficult to find that according to Table 4.15 that there are 3*5=15 cells and there are at least 3*5*3=45 questions to be asked in one interview. Practically, a different focus on each column or each row of the Table 4.15 was set for each interview depending upon the circumstances.

4.7 SUMMARY

In summary, methodological considerations were discussed in this chapter and various procedures that were used in the process for the primary data collection were described.

It was concluded that this study was mainly a quantitative study with significant qualitative components. It was divided into three stages: formulation of hypotheses, testing of hypotheses, and after-survey probing. The qualitative components were presented in the formulation stage as well as at the after-survey probing stage. In the formulation stage, secondary data were collected and the method used was a qualitative tool—repertory grid technique. The secondary data analysis provided the researcher with a rich text of anecdotal evidence about what a NPD process was in a number of different situations across several industries. It was helpful in selecting constructs and shaping the hypotheses. Another qualitative component of this study was the after-survey interviews. By asking semi-structured questions and discussing research findings with experienced NPD managers, it provided the researcher a feeling of 'being there' instead of keeping a far distance from the researched and most importantly provided insight into the problem which cannot be found in the literature.

The quantitative research is a major part of this study, which followed the common textbook process in marketing research (e.g. Churchill 1995 p81). The research procedure was carefully tailored and unique in many perspectives. The reasons for using such a combination of qualitative and quantitative research procedures were mainly 1) the nature of the topic 2) the situation when the research was initiated 3) the orientation and interests of the researcher 4) the access problem.

Similar to other quantitative studies, measurements of constructs played an essential role in this research. Suggestions from Churchill (1979) were carefully followed in building proper constructs. Most of the measurement items were adopted from the literature. Two concepts, however, were developed in this study. They are the linearity of NPD processes and the parallel level of NPD processes. The construction of measurements for these two concepts was related to a simplified version of the NPD model developed in Chapter 2.

Measurement issues occupied, of course, the core of the questionnaire design. This study developed a major postal questionnaire and two supplementation questionnaires in support of the implementation of the main questionnaire. The development of the major questionnaire took four stages 1) initiation stage in determining what was to be measured and balancing concepts and operational definitions, 2) development stage 3) qualitative piloting, a stage of face to face consulting 4) postal pilot test, following a similar procedure to the postal survey. The two support questionnaires were used to identify the most suitable persons for filling out the main questionnaire, and to persuade those qualified persons to participate in the survey. A distinct feature of the support questionnaires was that they were company specific.

Great effort has been put into finding a representative sample. In the exact sense, the population of this study should be all the new product projects with new products being made available for sale in the past five years in the UK's ICT sector. However, it was difficult to find a direct sampling frame for such a population. The target population was focused on companies which had developed at least one product in the past five years. A sampling frame of 1853 companies was developed from the on-line CD-ROM FAME. Considering both firm size and differences in industry sectors, stratified sampling was preferred. Among methods available, the optimum allocation method was believed to provide the maximum gains in precision. A stratified sample of 768 companies was then drawn from the sampling frame of 1853 companies based on that method.

Furthermore, a telephone survey was designed to find out if firms in the sample were really qualified for the survey and if they did qualify then who was the right person who had a general familiarity for NPD activities in the firm. Therefore the telephone survey work pre-notified potential respondents of the coming of the questionnaire and persuaded them to participate in the survey. The telephone survey work followed a formal process in the sense that every step of the work was well documented and with detailed guidelines and instructions.

The postal survey involved sending the main questionnaire out and collecting the required information back. In this study, a unique data collection procedure was developed, which was called Constricted Industrial Mail Survey (CIMS) procedure. CIMS emphases two features: limitation of funding and differences in respondents. It was developed from the principle of Dillman's TDM(1978) and later work of Walker et al (1987) on the cost-benefit analysis of TDM on industrial populations. It was believed that with the development of computer technology, the process used in mail survey will be more and more flexible than twenty years ago when TDM was proposed, although the principle of social economic interaction theory revealed by Dillman (1978) may remain the same.

Finally the procedure for after-survey interviews was also introduced in this chapter. The positive response from respondents gave more freedom to choose interviewees. The interview followed a semi-structured evolutionary process. Open ended questions were asked during the interview. Each of the interviews was tailored according to individual situation on an over-all plan of what questions to be asked.

In the chapter following, the response and non-response analysis will be presented as well as the reliability analysis of measurements.

Chapter 5 Validating the Primary Data: Non-response Analyses and the Reliability of Measurements

In previous chapters, a methodology was developed and a set of hypotheses to test were stated. Using a hypothesis testing quantitative methodology a target population for the tests was broadly defined as the British Information and Telecommunications Technology manufacturers that have developed new products in the past five years. It was clearly stated that the whole process of data collection was seen as a fight against subjectivity and bias. However, there was no denying that bias and subjectivity may exist in this study. Once the data collection is over, it is important to evaluate the extent to which bias may affect the results and ultimate conclusions. Specifically, this chapter serves two purposes:

- *The first purpose was to examine the responses and non-responses. Few research projects can claim to be bias free, but it is important to know if the sample can be used to meet the purpose of the study and to what extent it is representative. In this study, the primary data collection was divided into two parts: telephone survey work (a procedure of refining the sampling frame) and postal survey (a procedure to collect the data). Therefore the response and non-response analyses will be described into two parts accordingly. It is of interest to know the characteristics of those who did not reply in the telephone survey work and those who did not reply in the postal survey as well.*

The other purpose of this chapter will be to examine the consistency of the measurement scales used in data collection. As the in-consistency of multiple items in measuring the same construct will make the research finding not interpretable, the importance of using proper measurement procedure cannot be underestimated.

Putting these two aims together, this chapter will provide a data validating process prior to the data was analysed. The latter will be described in the next chapter.

5.1 RESPONSE AND NON-RESPONSE ANALYSIS

One of the main concerns of survey related studies is the non-response bias. Here the sample can be divided into two parts: the persons who responded and the persons who did not. If response and the non-response differ substantially, then the generalizability of the results from the sample to population would be in jeopardy. It is therefore very important to know before doing the data analyses to what extent non-response bias exists. That is, how the response and the non-response differ from each other. In this section response and non response analysis will be carried out. As it was described in the last chapter, the survey procedure was divided into two stages: telephone survey and postal survey. The telephone survey work served as a means of motivating the right people to participate in the survey and also a means of reconstructing and refining the sample frame so that it can reflect the population more accurately. The postal survey was the main process of data collection. For convenience, the response and non-response analyses will be divided into two parts.

5.1.1 Response and non-response of the telephone survey work

From Table 4.12, it has been seen that the over-all response rate for telephone survey work was 65.23%. As to the response rate of individual strata, the minimum response rate was 50%, the maximum was 74.24%. From a sample size of 768 companies, respondents in 501 companies who were likely to participate in the survey were identified. The degree to which they were willing to participate in was based on the interviewer's subjective judgement.

1: *Definitely will: The interviewer talked to the potential respondent in person, definite answer was obtained.*

2: Highly possible: The interviewer talked to the potential respondent in person, very friendly response was obtained.

3: Possible: The respondent could not be contacted in person, (s)he was highly recommended by other people in the organization as the best person for the purpose of this survey.

4: Less likely: The interviewer talked to the respondent, but a less enthusiastic answer was obtained.

5: Definitely not: Negative answer was obtained from the contact or the contact could not be established.

From statistics for the first four categories, Table 4.13 was formed and used to predict the response rate for the mail survey. The non-response in the telephone survey work, however, was the last category listed above, which counted for 768-501=267 companies in total. Because of the relatively formal process used in the telephone survey work of this study, it was not difficult to find the exact reasons for non-responses. Table 5.1 lists the six main reasons for non-response in the telephone survey work:

Table 5.1 Main reasons for non-response for the telephone survey work(n=768)

Reasons	**Number of non-response (Percentage)**	**Percentage to the pre-set sample** (n=768)
1: Contact cannot be established	162 (60.7%)	21.1%
2: Do not develop new products or familiar with NPD	60 (22.5%)	7.8%
3: Against the company's policy (For questionnaires or given names in the phone)	**18 (6.7%)**	**2.3%**
4: Not qualified for the survey (Products do not lie in the ICT category)	10 (3.7%)	1.3%
5: Not in the mood to answer	**4 (1.5%)**	**0.5%**
6: Others (Holding company, same company with different names in the sample)	13 (4.9%)	1.7%
Total	267 (100%)	34.8%

1) The first reason was that the company in the original sampling frame cannot be contacted, because such a company was no longer available. For example, the company had merged or was acquired by another company or it ceased to be in business. It is a quite normal phenomenon in such a dynamic market. This accounted for 60.7% of the non-response.
2) The second reason was that the company was not involved in new product development at all. This accounted for 22.5% of the 267 non-response.
3) The third reason was that companies in this category simply did not accept any kind of questionnaires whether they developed new products or not. These counted for 6.7% of the non-response.
4) The fourth reason was that some of the companies did not manufacture ICT products. This counted for 3.7% of the non-response.
5) The fifth reason was that the respondent was simply not in the mood to answer the phone call properly at that moment. Attempts were made to call back the respondent at different times. This figure was reduced finally to 1.5%.
6) Although efforts were made to reduce redundant information when forming the sampling frame, there still existed some redundant records in the sample and this constituted the last reason for non-response. It counted for 4.9% of the non-response.

In summary, the possible causes of non-response which may raise bias were reason 3 (against the company policy) and reason 5 (not in the mood to answer), which accounted for 8.2% of the over-all non-response and only 2.8% of over-all sample. It is therefore concluded that possible bias which may arise due to this small percentage of non-response can be ignored (Kanuk & Berenson 1975). Apart from category 3 and 5, all of the other categories did not belong to the targeted population. Therefore refining and reconstructing the sampling frame via telephone survey work can be justified. The sample resulting from the telephone survey work was an accurate reflection of the target population.

5.1.2 Response and non-response analysis of the postal survey

5.1.2.1 Response rate of the postal survey

Of the 501 companies to which questionnaires were sent and contacted via the procedure described in section 4.4.4, 257 replies were received, which means either they sent the completed questionnaire back or gave a definite reason why they could not complete the questionnaire. The response rate therefore is 257/501=51%. Among them, 171 questionnaires were identified as valid for further data analysis. This yielded a response rate of 34%. The distribution of response according to the size of the firm and industry sectors is shown in Table 5.2. At a first glance, it is easy to find in Table 5.2 that the number of useful responses in each of the nine strata is larger than 5, which is sufficient even for cross table comparisons (Cramer 1994).

Table 5.2 Response distribution

Number of useful Responses	**Sector A** (computer and office equipment sector but not the communications equipment US SIC Code 3571 3555 3575 3578 3579 3652)	**Sector B** (the communications equipment but not computer and office equipment US SIC code 3661 3663 3669 3613)	**Sector C** (doing both the communications equipment and computer and office equipment)	**Total**
Large firms (Last year sales turnover greater than £50 m)	Cell 1 13	Cell 2 10	Cell 3 **6**	29
Medium firms (£10 to 50 m)	Cell 4 34	Cell 5 27	Cell 6 31	92
Small firms (<=£10m)	Cell 7 28	Cell 8 **6**	Cell 9 16	50
Total	75	43	53	171

A calculation of response rate for each stratum is shown in Table 5.3.

Table 5.3 Response rate for each stratum

Response rate	**Sector A** (computer and office equipment sector but not the communications equipment US SIC Code 3571 3555 3575 3578 3579 3652)	**Sector B** (the communications equipment but not computer and office equipment US SIC code 3661 3663 3669 3613)	**Sector C** (doing both the communications equipment and computer and office equipment)	**Total**
Large firms (Last year sales turnover greater than £50 m)	Cell 1 25% (13/51)	Cell 2 47% (10/21)	Cell 3 **31%** (6/19)	30%(29/98)
Medium firms (£10 to 50 m)	Cell 4 28% (34/121)	Cell 5 56% (27/48)	Cell 6 43% (31/72)	38%(92/241)
Small firms (<=£10m)	Cell 7 35% (28/78)	Cell 8 **17%** (6/35)	Cell 9 32% (16/49)	31%(50/162)
Total	30% (75/250)	41% (43/104)	36%(53/147)	34%(171/501)

It can be seen from Table 5.2 that the minimum number of respondents among the nine strata was six. It happened in cell 3 (large firms, sector C), and cell 8 (small firms, Sector B). Table 5.3 shows that the response rate for cell 3 was 31%. The response rate for cell 8 was 17%, only 6 responses from 35 companies were received. In addition to the six responses received, all of the remaining 29 companies in this cell were re-contacted and phoned one by one to find out reasons why they did not reply. Only three companies were identified as developing new ICT products, but they declined to participate in this research. One of the company thought their products cannot be called new in real sense: "*while we recognised ourselves as producing 'new products', they are in essence all varieties on a single theme, i.e. different sizes of the same basic product*". The other two simply declined to spare the time for the questionnaire because they preferred to spend it on money making activities.

5.1.2.2 Reasons of non-response

Of the 257 reply received, 86 of them cannot be used for further analysis. There are several reasons for the "non-response".

1) The company did not develop new products. Although thorough telephone survey work had been carried out, this still counted for the main category of non-response.
2) The company believed they did not belong to the ICT sector. For example, a furniture company which manufactured desks and shelves specially designed for the use of computer.
3) The person was too busy to answer the questionnaire. Some of them expressed this more directly, "*As always, the demands on our time are focused on more immediate and selfish goals*". This is especially true in the case of small companies.
4) It was against the company's policy to reply. In the telephone survey work, the interviewer had tried their best to get the relevant personal address. However, the survey letters may never have reached the respondent because sometimes letters are censored within the company.
5) The questionnaire completed was not usable. One case was a company in which NPD was undertaken in Japan. The person in UK's Division had some general familiarity with NPD procedure but his (her) knowledge was not sufficient to meet the requirement of this questionnaire.
6) The person being contacted during the telephone survey work was no longer available in the company when the postal survey was carried out. There were no other people in the company who had the expertise to complete the questionnaire.
7) The questionnaire was misplaced. The respondents reportedly sent it back, but it could not be traced.

Table 5.4 Reasons for non-response (n=86)

Reasons	**Number of companies (percentage)**
1: The company did not develop new products	24 (27.91%)
2: The company believed that they did not belong to ICT sector	19 (22.09%)
3: The person was too busy to answer the questionnaire	18 (20.93%)
4: It was against the company's policy to reply	10 (11.63%)
5: The questionnaire was not usable	8 (9.30%)
6: The person was no longer available	5 (5.81%)
7: The questionnaire was misplaced	2 (2.33%)
Total	86 (100%)

In summary, apart from for the first two categories of non-response, the other five might cause bias to the research results. The last five categories have 43 companies which counted for 43/257=16.73% of 257 total reply and 43/501=8.58% in the mail sample. To further analyse the possible bias brought by over-all non-response, it is therefore necessary to examine the representativeness of the sample.

5.1.2.3 Representativeness of the sample

Whereas the last sections analysed reasons in non-response in the telephone and postal surveys, it is the purpose of this section to check characteristics of the final sample obtained and to examine the representativeness of the sample from the analysis of these characteristics using information collected. In the first instance, details of the final sample will be analysed. Secondly, an independent t-test was carried out to compare the mean difference between the response group and the non-response group. Thirdly the comparison of early response and late response was carried out to further explore the difference between the non-response and the response because it was believed that those who responded less 'readily' were more like those who did not respond (Armstrong and Overton 1977).

The response

To explore the representativeness of the sample, a closer look at the characteristics of sample may help. The characteristics of the final sample are shown in Table 5.5. The first and perhaps the most important issue here is that of whether the sample can be used for the purpose of the study. Because this study concerned the relationship between NPD processes and product newness, naturally it requires that the product newness varies from high to low and product categories can include some 'new to the world products'. It can be seen from Table 5.5 that new to the world products accounted for 11% of over-all sample obtained, whereas 'new product line' accounted for 23% of the over-all response. These figures are similar to the discovery of Booz Allen and Hamilton (1982), in which new to the world products occupied 10% of their sample, new product lines occupied 20% of over all products.

Given that the categories of 'new to the world products' and 'new product line' were not trivial, it was therefore reasonable to assume that product newness varies among the sample obtained. Given the competitiveness and innovativeness in the information and communications technology industry, this result was not unexpected. In addition to product newness, types of companies in Table 5.5 reflected the global nature of the industry. The research was designed mainly for companies in the UK. Wholly UK owned companies in the sample accounted for 46% of the total response and 98% of NPD was done in the UK.

Table 5.5. Respondent sample details (n=171)

Characteristics	*% of respondents*
Industry sector	
A. Computer and office equipment sector but not the communications equipment	44%
B. The communications equipment sector but not the computer and office equipment	25%
C. Doing both communications equipment and computer and office equipment	31%
Size of the company	
A. Large firms (Last year sales turnover greater than £50m.)	17%
B. Medium sized firms (Last year sales turnover between £10m to £50m)	53%
C. Small firms (Last year sales turnover between £1m to £10m)	30%
Type of company	
A. Wholly UK owned	46%
B. International with UK headquarter	16%
C. UK subsidary of a multi-national	35%
D. Others	3%
Type of products nominated	
A. Communications equipment	24%
B. Computer products	23%
C. Electronics	28%
D. Others	25%
Product newness	
A. **New to the world product**: a product new to both the organization and the world.	11%
B. **New product line**: a product new to the organization which allows the organization to enter markets in which it has no previous experience	23%
C. **Product line extension**: a product that is new to the organization but "fits" with the existing product lines	42%
D. **Improved product**: a development of an existing product	24%
Respondents position in the company	
A. Marketing & Sales Manager/Director	22%
B. NPD Director/Manager	15%
C. Product Manager/Production Director/Specialist	13%
D. Product Engineer/Designer/Design Engineer	13%
E. Engineering Manager	11%
F. Technical Manager/Director	10%
G. Manager Director/General Manager/Business Manager	8%
H. R&D Manager	2%
I. Others	6%

The respondents

Another factor which may influence the research finding is the respondents position in the organization. The statistics for the position of these respondents is exhibited in Table 5.5. It is easy to see that of the respondents' background, both marketing and R&D/technical occupied significant proportions. It can be seen from the bottom of Table 5.5 that 22% of the respondents were marketing and sales managers/marketing directors, while technical managers (10%), engineering managers (11%) and R&D managers (2%) accounted for 23% of the final sample. Therefore there was a significant amount of respondents in the sample which represented either marketing or R&D. The respondents were asked in the questionnaire to describe briefly their role in the project. Most of the respondents in the survey reported that they had been the head of the project or major designers. That is, the respondents were either the top person or the other person as it was specified in Langrish et al (1972) (See section 2.2.1). Some of them claimed that they played the role of the 'product champion' in the development process of the new product they nominated. This verified that the strategy used in telephone survey work in finding the best person in the organization for new product development was successful. It was believed that finding the right persons for the questionnaire would certainly improve the validity of the data collected. In a word, the quality of respondents is a fundamental guarantee in assessing the validity of the survey. This survey depended upon a pool of highly qualified NPD professionals to fill out the questionnaire.

The response(n=171) and the original sampling frame (N=1853): sizes and sectors

To examine the representativeness of the final sample, it is helpful to compare the final sample obtained and the original sampling frame. It is not difficult to see that there is no sharp difference between the distribution of the sample on industry sectors and the distribution of the original sampling frame obtained from FAME. It is shown in Table 5.5 that sector A accounted for 44% of the total response, compared to 52% of that of sector A in the sampling frame (See Table 4.5 of Chapter 4). Sector B accounted for 25% of the total response, compared to 21% of Sector B in the sampling frame. Sector C accounted for 31% of the total response, compared to 27% of sector C in the sampling frame.

Furthermore, as to the size of the company, a first glance from Table 5.5 and Table 4.4 shows that the proportion for large, medium, and small sized companies was quite different from that of the total population. However, this phenomenon can be explained by the sampling principle used in last Chapter.

In fact, the proportion of large, medium, and small companies in the final sample reflected the optimum allocation sampling principle: a deliberate use of widely different sample rates for various strata (Kish 1965). The proportion of large firms in the final sample was 17%, much larger than the 9.17% of the large firms occupied in the sampling frame. Because the variance in large firms is much greater than that of the other two categories, it gains in precision to increase the proportion of large firms in the sample (Cochran, 1977). According to the calculation procedure of the optimum allocation method, the ideal proportion between medium sized firms and small firms should be approximately 1.4:1, in the final sample it reached approximately 92:50=1.8:1.

The response (n=171) and the refined sampling frame (N=501): sizes and sectors

Bearing in mind that the population of the study was new ICT products which were made available for sale in the UK in the past five years, while the original sampling frame (N=1853) was drawn from a more broadly defined population: the UK manufacturers in the ICT industry, which contained many firms which did not develop new ICT products. The telephone survey work has largely filtered out those companies which did not belong to the population. The result obtained therefore can be regarded as a refined sampling frame (N=501). It was therefore desirable to have a simple comparison between the response and the refined sampling frame.

First, it is easy to see that there is no sharp difference between the distribution of the sample on industry sectors and the distribution of that of the refined sampling frame, because there was virtually no distinct difference of distribution on industry sectors between the refined sampling frame and the original sampling frame.

Secondly, for the size of the company, the proportion of large firms in the final sample was 17% compared to 20% for the refined sampling frame. The proportion of medium sized firms in the final sample was 53% compared to 48% in the refined sample. The proportion of small firms in the final sample was 30%, compared to 32% in the refined sampling frame. Therefore no distinct differences existed between the final sample and the refined sampling frame. As the refined sampling frame was closer to the true population, it was reasonable to assume the representativeness of the final sample. To try to make maximum use of existing information in examining the representiveness of the final sample, two further tests were done, which are described as follows.

The response versus the non-response

As sales turnover has been used as an index of company size in forming the sample of this research, it is desirable to see whether the response and the non-response differ along this index. An independent sample t-test was carried out for the response group (n=171) versus the non-response group (n=501-171=330). The result of the t-test is shown in Fig. 5.1.

Group Statistics

Groups	N	Mean	Std. Deviation	Std. Error Mean
Response	171	55514.1	234442.2	17928.2
Nonresponse	330	70541.0	295610.7	16272.8

Independent Samples Test

	Levene's Test for Equality of Variances		t-test for Equality of Means						
								95% Confidence Interval of the Mean	
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Equal variances assumed	1.065	.303	-.577	499	.564	-15026.94	26033.93	-66176.6	36122.7
Equal variances not assumed			-.621	418.664	.535	-15026.94	24212.13	-62619.4	32565.5

Fig. 5.1 Test of mean difference between final response (n=171) and non-response group (n=330)
Dependent variable: sales turn over of latest year available (£, 000)

Fig. 5.1 shows that the mean of the response group was 55514.1 (SD=234442.2), and the mean of the non response group was 70541.0 (SD=295610.7). The Levene's test did not reject the equal variance assumption (F=1.065, P=0.303).

No significant mean difference was found between the final response group and the non-response group for sales turn-over, on which the stratified sampling was based.

A comparison was also made between the first wave response (response received before the first follow up letters were sent out) and the second wave response (response received afterwards). No significant differences were found between the two samples. Therefore it was reasonable to assume that the sample obtained was a proper representative of the whole population (Armstrong and Overton, 1977).

In summary, the response rate for the telephone survey work in this study was 65%. The response rate for the postal survey was 34%. Given the fact that many firms in the original sampling frame did not develop new products, the response rate was more than satisfactory. For telephone survey work, it was concluded that the influence of non-response bias can be ignored because the non-response which may raise bias only accounted for a very small percent (2.8%) of the sample. As for the postal survey, it was concluded that the final sample can be regarded as representative because

- The telephone survey work provided a refined and therefore more accurate picture of the population.
- There was no obvious distinction between the final sample and the refined sampling frame.
- Product newness index varies.
- No significant difference between the non-response and response group was found.
- No significant difference between the first wave response and the second wave response was found.

Having analysed the response and the non-response of the data collection, it is the task of next section to examine the reliability of measures using the data collected.

5.2 RELIABILITY OF MEASURES

As it is mentioned earlier in the last chapter (Section 4.2), the building of measurements of scales in this study followed a procedure recommended by Churchill (1979). Once the data had been collected, it was desirable to check the consistency of the measurement items defined at section 4.2 and 'purify' the measure. The reliability of multi-item scales was assessed using Cronbach's alpha and factor analysis. This section contains the analysis results for each scale.

Cronbach's alpha is an internal consistency measure in assessing the homogeneity of a set of items and is perhaps the most commonly accepted formula for assessing the reliability of a measurement scale with multi-point items. Peter (1979) gave several alternatives of computing the coefficient alpha. It is formulated as

$$\alpha = \left(\frac{k}{k-1}\right)\left(1 - \frac{\sum_{i=1}^{k}\sigma_i^2}{\sigma_t^2}\right)$$

Where k= number of parts (usually items) in the scale.

σ_i^2 =variance of item i and

σ_t^2 =total variance of the scale

In this study all of the calculations of alpha were done via SPSS (Software Package for Social Sciences). According to Churchill (1979),

> *"Coefficient alpha absolutely should be the first measure one calculates to assess the quality of the instruments. ... Coefficient alpha is the basic statistic for determining the reliability of a measure based on internal consistency."*

A low coefficient alpha indicates the sample of items performs poorly in capturing the constructs which motivated the measure. On the other hand, a large alpha indicates that the multi-item test correlate well with true scores. According to Nunnally (1967), for a basic research instead of applied settings, a coefficient alpha of 0.5 to 0.6 would be sufficient for the purpose and that increasing reliabilities beyond 0.80 is probably wasteful.

While the coefficient alpha is low, a recommended way (Churchill 1979) is to drop those items that show some exceptional features, e.g. near zero correlation with other items or produced a substantial or sudden drop in the item-to-total correlations. To put it simply, the iterative process Churchill recommended was:

> *" the calculation of coefficient alpha, the elimination of items, and the subsequent calculation of alpha until a satisfactory coefficient is achieved".*

In additional to the calculation of the coefficient alpha, factor analysis was also recommended in Churchill(1979). Factor analysis, as it is defined in McDaniel and Gates (1993) *"is a procedure for data simplification through reducing a set of variables to a smaller set of factors or composite variables by identifying dimensions underlying the data*". While most of the usage of factor analysis was exploratory in the sense that it was used " *as an expedient way of ascertaining the minimum number of hypothetical factors that can account for the observed covariance, and as a means of exploring the data for possible data reduction (Kim and Mueller 1994a)",* it was recommended for use to confirm that items of the same construct downloaded at the dimensions expected (Churchill 1979). The fundamental assumption of factor analysis is that some underlying factors, which are smaller in number than the number of observed variables, can adequately explain the observed correlations (or covariances) among the observed variables. In the case of this study, except the performance construct, all of the constructs listed in section 4.2 were expected to have one dimension. That is, all of the items for the same construct should share a common core. The confirmatory use of factor analysis here is then to verify all of the items for the same construct "reduced" to the same dimension. If the factor analysis for a construct produced additional dimensions a change in the measurement items would be necessary. Usually items which did not share the common core were deleted and the process of *coefficient alpha calculation/factor analysis* was iterated again to make sure if further changes were still needed. Having described the procedure, assessments of the internal consistency for individual construct will be presented in turn in the forthcoming sections. Despite the reliability consideration, another purpose of the following section is to present a detailed definition of those variables which will be used frequently in the data analysis stage although the meaning of variables will also be described in later chapters.

5.2.1 Reliability of newness measures

5.2.1.1 Newness to company

This scale was composed of 4 five points Likert items. Five point Likert scales were used with the following points: 5= strongly disagree, 4= disagree, 3= neutral, 2= agree, 1= strongly agree. The belief statements that operationalised newness to company were:

cnew21a: "This product belongs to an existing product category of our organisation",

cnew22a: "The technology was already embodied in our organisation before product development",

cnew23a: "This product needed little modification of existing engineering/design work",

cnew24a: "There was almost no modification on existing manufacturing processes".

The coefficient alpha was 0.5851 (0.5858 for standardized item Alpha) which was sufficient for basic research according to Nunnally (1967). The coefficient Alpha was lower than the results from Kleinschmidt and Cooper (1991) for the same set of measurement items. The coefficient alpha in their study was 0.77. A possible explanation was that the scale in Kleinschmidt and Cooper (1991)'s study was 0 to 10, which has a greater range (Churchill & Peter 1984). Table 5.6 shows the results of factor analysis. The analysis was done on the sample of n=171. The four items for the construct (newness to company) were cnew21a, cnew22a, cnew23a and cnew24a as defined above. It can be seen from Table 5.6 that the result of factor analysis produced only one significant factor, which can explain 49% of the total variance[1]. The communality figures in Table 5.6 show the square of the correlation between individual items and the factor produced. For example, communality of cnew21a is 0.19368, that means that the square of the correlation between cnew21a and the common factor extracted is 0.19368. Compared to the communality of cnew22a, cnew23a and cnew24a, the communality of cnew21a is fairly low. The low communality indicates that the item cnew21a shares less common score than the other items do. From the definition of the items, it is easy to find that cnew21a measures generally whether the product belongs to an existing category of the firm whereas the other three measure more specifically the changes in existing processes. That is, the last three items are more 'consistent' with each other than with cnew21a. Thus item cnew21a was excluded from the scale.

Table 5.6 Factor analysis for newness to company (four items, n=171)

PC extracted 1 factors.

Final Statistics:

Variable	Communality	*	Factor	Eigenvalue	Variance explained (%)
		*			
CNEW21A	.19368	*	1	1.95527	48.9
CNEW22A	.63213	*			
CNEW23A	.61175	*			
CNEW24A	.51772	*			

A recalculation of the coefficient alpha for the remaining three items yielded 0.6864 (standardised item alpha 0.6888). The confirming factor analysis again produced only one factor. Table 5.7 shows the result of factor analysis where cnew21a was excluded. It is easy to find that there is no sudden drop of communality and all three items downloaded on one factor which can explain 61.7% of the total variance. The newness to company was therefore measured by the average score of these three items:

cnew=(cnew22a+cnew23a+cnew24a)/3

[1] The criterion used in this study in determining the number of factors to be extracted is the rule known either as the Kaiser or eigenvalue criterion (eigenvalue greater than or equal to 1). Kim and Mueller (1994b) provided an excellent discussion about related issues.

Table 5.7 Factor analysis on Newness to company (three items, n=171)

```
PC     extracted    1 factors.

Final Statistics:

Variable      Communality  *  Factor   Eigenvalue Variance explained (%)
                           *
CNEW22A           .62472   *    1        1.85091        61.7
CNEW23A           .66931   *
CNEW24A           .55688   *
```

5.2.1.2 Newness to market

This scale was composed of 6 five points Likert items. The belief statements for newness to market were:

mnew15a: "The new product was mainly purchased by old customers of the organisation",

mnew16: "There were no new competitors at all for this product at its launch",

mnew17: "It was targeted to satisfy a new market for us" (adverse order, 1 strongly disagree, 5 strongly agree),

mnew18a: "There was no new sale force organised particularly for this product" ,

mnew19: "Completely different media types of advertising/promotion programme were used for this product" (in adverse order),

mnew20: "New methods were used for market research in its development" (in adverse order).

The coefficient alpha was 0.6239 (0.6356 in standardized item alpha). Although the coefficient alpha will suffice for the purpose of this study, a confirmatory factor analysis yielded, however, two distinct dimensions. The result of the factor analysis is shown in Table 5.8.

Table 5.8 shows that these six items were downloaded in two dimensions with mnew16 and mnew17 in factor 2 and mnew15a, mnew18, mnew19, and mnew20 in factor1. The rotated factor matrix showed the correlation of each measurement item with these two factors.

Eliminating the two items mnew16 and mnew17 yielded a four item measurement for market newness.

mnew=(mnew15a+mnew18+mnew19+mnew20)/4

A re-run of the reliability analysis for these four items indicated a sufficient coefficient alpha of 0.6927 and the factor analysis for the four items confirmed that the remaining four items, mnew15a, mnew18, mnew19, mnew20, were downloaded in the same dimension.

Table 5.8 Factor analysis for market newness scale (n=171)

```
Extraction    1 for analysis    1, Principal Components Analysis (PC)

PC     extracted    2 factors.

Final Statistics:

Variable      Communality   *  Factor    Eigenvalue Variance explained (%)
                            *
MNEW15A           .40368    *     1        2.28161        38.0
MNEW16            .65946    *     2        1.22308        20.4
MNEW17            .60529    *
MNEW18            .58592    *
MNEW19            .69756    *
MNEW20            .55279    *

VARIMAX   rotation   1 for extraction   1 in analysis   1 - Kaiser
Normalization.

Rotated Factor Matrix:

              Factor  1     Factor  2

MNEW15A         .54900        .31980
MNEW16         -.15571        .79700
MNEW17          .29532        .71978
MNEW18          .71884        .26304
MNEW19          .83379       -.04851
MNEW20          .73517       -.11098
```

5.2.1.3 Newness to technology

This scale was composed of two five point Likert items. The belief statements were:

tnew25: "The key ideas that make this product have significantly advanced over existing knowledge of the current technology capability" (in adverse order, 1 strongly disagree, 5 strongly agree),

tnew26: "The linkage between the key ideas of the product have significantly advanced over existing knowledge of the current technology capability" (in adverse order).

The reliability analysis for this scale showed a higher coefficient alpha 0.8155 (0.8163 in standardised item Alpha) and only one significant factor was extracted by the factor analysis (as shown in Table 5.9).

Table 5.9 Factor analysis for newness to technology scale (n=171)

```
Extraction   1 for analysis   1, Principal Components Analysis (PC)

PC    extracted   1 factors.

Final Statistics:

Variable      Communality  *  Factor   Eigenvalue Variance explained (%)
                           *
TNEW25             .84481  *     1       1.68963       84.5
TNEW26             .84481  *
```

The newness to technology was thus measured by the average of these two items. That is,
tnew=(tnew25+tnew26)/2

5.2.1.4 Summary for the reliability of product newness scale

In summary, product newness was measured via three scales:

Newness to company (cnew) with three items: cnew22a, cnew23a, and cnew24a.

Newness to market (mnew) with four items: mnew15a, mnew18, mnew19, mnew20.

Newness to technology with two items: tnew25 and tnew26.

To confirm that these three scales belonged to different dimensions, factor analysis was carried out for the three scales by grouping the 3+4+2=9 items together. The result of data analysis is shown in Table 5.10. It can be seen from Table 5.10 that these 9 items were downloaded into three dimensions. Factor 1 represents newness to market, which is closely related to item mnew15a, mnew18, mnew19, and mnew20. Factor 2 represents newness to company, which is closely related to cnew22a, cnew23a, and cnew24a. Factor 3 represents newness to technology, which is closely related to tnew25 and tnew26. The grouping of these items was exactly as expected.

Table 5.10 Factor analysis for product newness (n=171)

```
PC     extracted    3 factors.

Final Statistics:

Variable      Communality  *  Factor    Eigenvalue Variance explained (%)
                           *
CNEW22A           .60230   *     1        2.99133        33.2
CNEW23A           .67744   *     2        1.67806        18.6
CNEW24A           .57296   *     3        1.12898        12.5
MNEW15A           .53836   *
MNEW18            .61071   *
MNEW19            .66724   *
MNEW20            .54441   *
TNEW25            .80609   *
TNEW26            .77887   *


VARIMAX   rotation   1 for extraction   1 in analysis   1 - Kaiser
Normalization.

VARIMAX converged in 5 iterations.

Rotated Factor Matrix:
```

	Factor 1	Factor 2	Factor 3
CNEW22A	.07403	**.70884**	.30718
CNEW23A	.06592	**.81208**	.11671
CNEW24A	.09220	**.74846**	.06530
MNEW15A	**.62540**	.22153	-.31328
MNEW18	**.77984**	.01133	.04931
MNEW19	**.78780**	.12791	.17394
MNEW20	**.67083**	-.00578	.30718
TNEW25	.06702	.30982	**.84001**
TNEW26	.15390	.15842	**.85445**

5.2.2 Reliability of process variables

<u>5.2.2.1 Reliability of formality scale</u>

This scale was composed of 4 five point Likert scale items. The belief statements for formality were:

form34: "The development stage was totally unstructured: everybody involved in the NPD process was allowed to be creative and to do almost as (s)he pleased",

form35: "There were precise dates for the start and the completion of the activities to be undertaken during the development stage"(in adverse order),

form36: "During the development stage, project progress was formally monitored" (in adverse order),

form37: "The development stage proceeded by means of a well-documented plan of action".

Table 5.11 Factor analysis for formality scale (n=171)

```
Extraction    1 for analysis    1, Principal Components Analysis (PC)

PC     extracted    1 factors.

Final Statistics:

Variable      Communality  *  Factor   Eigenvalue Variance explained (%)
                           *
FORM34A            .40005  *    1        2.43689       60.9
FORM35             .59274  *
FORM36             .66090  *
FORM37             .78320  *
```

The reliability analysis for this scale showed a coefficient alpha of 0.7850 (0.7804 in standardised items). The result of factor analysis is shown in Table 5.11, which extracted only one significant factor. This factor alone can explain 60.9% of the total variance of the four items and there is no sudden drop in the communality index. So the formality of NPD processes was measured by the average score of these four items, that is,

formality=(form34a+form35+form36+form37)/4

5.2.2.2 Reliability of the role flexibility of Marketing

This scale was composed of three five points Likert scale items. The belief statements for the role flexibility of marketing were:

mrol38a: "Marketing personnel played a very limited role in the development of this product",
mrol39: "The marketing project members had a strong technical orientation" (in adverse order),
mrol40: "Some of the marketing project members also performed technical tasks during the development of this project" (in adverse order).

Table 5.12 Factor analysis for the role flexibility of marketing (n=171)

```
Extraction    1 for analysis    1, Principal Components Analysis (PC)

PC    extracted    1 factors.

Final Statistics:

Variable      Communality  *  Factor   Eigenvalue Variance explained (%)
                           *
MROL38A           .39899   *     1       1.85169        61.7
MROL39            .74039   *
MROL40            .71231   *
```

The coefficient alpha for the scale was 0.6778 (0.6815 in standardised item alpha). The factor analysis verified that only one significant factor was produced (See Table 5.12), which can explain 61.7% of the total variance. Thus the role of marketing was measured by the average of these three items:

mrole=(mrol38a+mrol39+mrol40)/3

5.2.2.3 Reliability of the role flexibility of R&D

This scale was composed of 3 five Likert scale items. The belief statements for the role flexibility of R&D were:

rrol41a: "R&D personnel played a very limited role in the development of the product",
rrol42: "The R&D project members had strong business orientation"(in adverse order),
rrol43: "Some of the R&D project members also performed marketing tasks during the development of this project" (in adverse order).

The coefficient alpha for this scale was 0.4110 (0.4126 in standardised item alpha), which will not suffice according to Nunnally (1967). An inter-scale correlation analysis revealed that correlation coefficients of rrol41a and the other two items were very low (0.0962 and 0.0711 respectively, see Table 5.13). Although the result of factor analysis produced only one significant factor (see Table 5.14), the communality of item rrol41a was 0.1059. That is much lower that the communalities of the other two items.

Table 5.13 Correlation Matrix for the role of R&D scale (n=171)

Correlation Matrix

	RROL41A	RROL42	RROL43
RROL41A	1.0000		
RROL42	.0962	1.0000	
RROL43	.0711	.3830	1.0000

A careful examination separated these three items into two groups: item rrol41a represents the importance of R&D personnel in the NPD process, item rrol42 and item rrol43 represent directly the role flexibility of R&D personnel. Therefore rrol41a was excluded.

Table 5.14 Factor analysis for the role flexibility of R&D (n=171)

Extraction 1 for analysis 1, Principal Components Analysis (PC)

PC extracted 1 factors.
Final Statistics:

Variable	Communality	*	Factor	Eigenvalue	Variance explained (%)
		*			
RROL41A	.10590	*	1	1.41665	47.2
RROL42	.66362	*			
RROL43	.64713	*			

VARIMAX rotation 1 for extraction 1 in analysis 1 - Kaiser Normalization.

A re-calculation of the coefficient alpha for this scale yielded 0.5472 (Coefficient alpha in standardised item 0.5439). The result of factor analysis produced only one significant factor (see Table 5.15).

Table 5.15 Factor analysis for role flexibility of R&D scale (n=171)

Final Statistics:

Variable	Communality	*	Factor	Eigenvalue	Variance explained (%)
		*			
RROL42	.69151	*	1	1.38301	69.2
RROL43	.69151	*			

Thus the Role of R&D was measured by following formula

rrole=(rrol42+rrol43)/2

5.2.2.4 Reliability of the parallel level

This scale was composed of 5 seven points semantic scaled items. The value of each variable was

para48

The idea stage and the concept stage were carried out in sequence, there was almost no overlapping	1 2 3 4 5 6 7	The two stages were conducted almost at the same time

para49

The concept stage and the prototype stage were carried out in sequence, there was almost no overlapping	1 2 3 4 5 6 7	The two stages were conducted almost at the same time

para50

The prototype stage and the trial production stage were carried out in sequence, there was almost no overlapping	1 2 3 4 5 6 7	The two stages were conducted almost at the same time

para51

The idea stage and the prototype stage were carried out in sequence, there was almost no overlapping	1 2 3 4 5 6 7	The two stages were conducted almost at the same time

para52

The concept stage and the trial production stage were carried out in sequence, there was almost no overlapping	1 2 3 4 5 6 7	The two stages were conducted almost at the same time

The coefficient alpha for the scale was 0.6617 (0.6681 in standardised item alpha).

A further factor analysis, however, showed the multi-dimensional nature of this scale. As it is shown in Table 5.16, the factor analysis produced two factors.

Table 5.16 Factor analysis for the parallel level of NPD process (n=169[2])

Extraction 1 for analysis 1, Principal Components Analysis (PC)

Variable	Communality	*	Factor	Eigenvalue	Variance explained (%)
		*			
PARA48	.77998	*	1	2.20376	44.1
PARA49	.66525	*	2	1.14835	23.0
PARA50	.30489	*			
PARA51	.82508	*			
PARA52	.77692	*			

Rotated Factor Matrix:

	Factor 1	Factor 2
PARA48	-.07040	**.88036**
PARA49	.32122	**.74971**
PARA50	**.55191**	.01708
PARA51	**.89805**	.13632
PARA52	**.86992**	.14194

It can be seen from Table 5.16 that item para48 was downloaded on factor2 and its correlation coefficients with other items were relatively low(see Table 5.17).

Table 5.17 Correlation matrix of inter-scale items (n=169)

	PARA48	PARA49	PARA50	PARA51
PARA48	1.0000			
PARA49	.2553	1.0000		
PARA50	.0605	.1939	1.0000	
PARA51	.0603	.4266	.3337	1.0000
PARA52	.1168	.3740	.2866	.7628

From the definition of item para48, it is not difficult to see that this item measured the degree to which the idea stage and the concept stage over-lapped during the NPD process. The value of para48 varies from 1 to 7. The mean of para48 (4.7677) was higher than the mean of the other items. That meant that the idea stage and concept stage were highly over-lapped in the sample investigated. Most importantly, as it is shown Table 5.17, the correlation of para48 with other items was fairly low. Using item para48 obviously cannot differentiate over-lapping activities in the sample. So it was reasonable to eliminate this item for the parallel scale. Because

[2] The parallel level scale has two missing values, the subjects with missing values were dropped when the

para49 was downloaded in the same direction as para48, due to similar reasons this item was also eliminated. The final measurement of the parallel level of NPD processes consisted of three items para50, para51, and para52. A re-calculation of the coefficient alpha yielded 0.6962 (0.7098 in standardised item alpha). A further factor analysis confirmed that these items downloaded in the same direction.

The parallel level scale was then calculated by following formula:

parallel=(para50+para51+para52)/3

5.2.2.5 Reliability of linearity scale

This scale was composed of 5 seven points semantic scaled items. The value of each variable was:

line53

We re-defined the product concept a lot of times	1 2 3 4 5 6 7	The product concept remained unchanged (e.g. at least 5 times) since the first definition

line54

The concept stage and the prototype stage were interwoven with each other	1 2 3 4 5 6 7	There were no concept definition activities after the first prototype was tested

line55

After the prototype test, a new concept definition was formed for the product	1 2 3 4 5 6 7	No change was made after the prototype test

line56a

No change has been made since trial production	7 6 5 4 3 2 1	At least 10 percent of the product design[3] has been changed since trial production

line57

The product design changed a lot of times during the development process (e. g. at least 5 times)	1 2 3 4 5 6 7	There were no design iterations, we followed an exact step by step approach.

factor analysis was conducted.

[3] Where the 10 percent change as a threshold is from Eisenhardt & Tabriz's (1995) study about the computer industry.

The coefficient alpha for this scale was 0.6791 (0.6902 in standardised item alpha). A confirmatory factor analysis extracted only one significant factor (Table 5.18).

Table 5.18 Factor analysis for the linearity of NPD process (n=170)

```
Extraction   1 for analysis   1, Principal Components Analysis (PC)

PC    extracted   1 factors.

Final Statistics:

Variable     Communality  *  Factor   Eigenvalue   Variance explained
                          *
LINE53           .58865   *     1       2.28022       45.6
LINE54           .35354   *
LINE55           .57282   *
LINE56A          .21275   *
LINE57           .55246   *

VARIMAX   rotation   1 for extraction   1 in analysis   1 - Kaiser
Normalization.
```

The linearity scale was measured as the average scores of the five items:

linearity=(line53+line54+line55+line56a+line57)/5

5.2.3 Reliability of the performance scale

This scale was composed of 7 five point Likert scaled items. The value of each variable was:

perf27 The product has met market share goals (1 strongly disagree, 5 strongly agree)

perf28 The product was enthusiastically welcomed by consumers (as above)

perf29 The product has provided a measured increase in customer satisfaction (as above)

perf30 The product has met the profit goals (as above)

perf31 The product has met margin goals (as above)

perf32 The product has provided a distinct competitive advantage (as above)

perf33 The current estimate of ROI on the project has met original criteria (as above)

The coefficient alpha was 0.8279 (0.8274 in standardised item alpha). The factor analysis produced two factors as predicted (See Table 5.19).

Table 5.19 Factor analysis for performance scale (n=166[4])

```
Extraction   1 for analysis   1, Principal Components Analysis (PC)

PC    extracted   2 factors.

Final Statistics:

Variable      Communality  *  Factor   Eigenvalue Variance explained (%)
PERF27            .53799   *    1        3.46167        49.5
PERF28            .76762   *    2        1.27300        18.2
PERF29            .66683   *
PERF30            .84553   *
PERF31            .72395   *
PERF32            .47989   *
PERF33            .71287   *

Rotated Factor Matrix:

              Factor  1     Factor  2

PERF27          .43524        .59039
PERF28          .03650        .87538
PERF29          .16124        .80052
PERF30          .88414        .25262
PERF31          .84707        .08016
PERF32          .28045        .63343
PERF33          .80506        .25446
```

Factor 1 represents financial performance of the product, item per30 (profit expectation of the product), per31 (margin goals of the product), and per33 (ROI expectation of the product) all downloaded on factor 1.

Factor 2 represent a measure of market success. Item per27 (market share expectation), per28 (customer acceptance), per29(customer satisfaction), and per32 (competitive advantage) all downloaded on factor 2. This result confirmed the measurement expectation proposed earlier in Chapter 4.. Thus the market success of the new product was measured by:

cperform=(perf27+perf28+perf29+per32)/4

Financial success of the product was measured by

fperform=(perf30+perf31+perf33)/3

[4] The performance scale has 5 missing values because that some projects have been launched shortly, it was difficult to estimate the performance of the projects at the time the survey was conducted.

The over-all product performance was measured by

perform=(perf27+perf28+perf29+perf30+perf31+perf32+perf33)/7

5.2.4 Other variables

Apart from the main variables that will be used in the assessment of the proposed hypotheses, there are a number of other variables describing the environment of the NPD project. As indicated in section 4.2.4, all of these variables except product complexity were a single item scale. So, it is unnecessary to assess their reliability here. As for the product complexity, it consists of two scales: internal product complexity and external product complexity. The internal complexity consisted of two items: the number of people involved in the project and the approximate price of the product. The second item had 22 missing values in the whole set of 171 responses and therefore was dropped. So the internal complexity was replaced by the number of people involved in the project directly. The external complexity was composed of two 7 point semantic differentials:

EC61 To what extent is learning required by the purchaser in order to use the product?
Little learning is needed (e.g. a bottle of milk) 1 2 3 4 5 6 7 Extensive learning is needed

EC61 To what extent does the product require the purchaser to master specific knowledge in order to use it?
No specific knowledge needed 1 2 3 4 5 6 7 Professional knowledge or skills needed.

The coefficient alpha was 0.82 and the factor analysis showed that the two items downloaded in the same direction.

5.2.5 Summary

A summary of the reliability analysis of scales is shown in Table 5.20.

Table 5.20. Reliability analysis of scales

	Scales	Items	Alpha	Factors	Minimum	Maximum	Mean	Standard Deviation
Newness	New to company	3	0.69	1	1.00	5.00	3.45	0.95
	New to market	4	0.69	1	1.00	5.00	2.38	0.86
	New to technology	2	0.82	1	1.00	5.00	3.30	0.93
Process Variables	Formality	4	0.78	1	2.00	5.00	3.85	0.73
	Role flexibility of marketing	3	0.68	1	1.00	5.00	2.99	0.93
	Role flexibility of R&D	2	0.54	1	1.33	5.00	3.37	0.74
	Parallel Level	3	0.70	1	1.00	7.00	2.89	1.51
	Linearity	5	0.68	1	1.20	7.00	4.27	1.19
Performance Variables	Over-all performance	7	0.82	2	1.00	5.00	3.67	0.62
	Market performance	4	0.76	1	1.00	5.00	3.79	0.65
	Financial performance	3	0.84	1	1.00	5.00	3.43	0.80

As it is shown in Table 5.20, most of the constructs were measured by at least three items except the two constructs new to technology and role flexibility of R&D. The coefficient alphas of constructs are all greater than 0.50, which are sufficient for the purpose of this study. Except the performance construct, factor analyses for all of the constructs yielded only one dimension. The factor analysis for the performance construct produced two dimension as expected, one to measure market performance of the product (customer satisfaction, market share, etc.), the other is to measure financial performance (ROI, profit expectation, etc.). It should be pointed out that there are three scales which have missing values. The linearity of the NPD processes scale has one missing value. The parallel level of NPD processes has two missing values and the performance scale has five missing values. Because of the small percentage of missing values, the alternative of dropping subjects as indicated in Cohen and Cohen (1983) was used when the reliability analysis was conducted.

5.3 CONCLUSIONS

This chapter examined the validity of data collection by analysing the response and the non-response in the survey and by measuring the reliability of individual scales. It showed that the sample obtained was useful and representative. Given the in-depth knowledge required by the questions asked in the questionnaire, the response rates for the telephone survey (65%) and the postal survey (34%) were more than satisfactory. The influence of bias which the telephone survey work may bring to the ultimate conclusions accounted for only 2.8% of the total sample (n=768). As for the postal survey, no significant difference between the response and the non-response group was found. Further tests showed no significant difference between the first wave response and the second wave response. This chapter also analysed the reliability of measurements using the data obtained via a procedure recommended by Churchill (1979). The measurements items were 'purified' and the reliability of the constructs was therefore raised to the standard required. In the next chapter, hypotheses proposed in early chapters will be examined using the data collected.

Chapter 6 Analysing the Survey Data: Hypothesis Testing and Further Exploration

The purpose of this chapter is to provide results of the survey data analyses, which can be described from two perspectives. The first perspective is to examine the hypotheses proposed thus far and they form the central theme of the data analyses. Where appropriate, further explorations will be put forward which constitute the second perspective of the analyses. Given that the survey allowed measurements beyond the set hypotheses, the rationale for taking the second perspective was to detect any other distinctive findings that may emerge from the dataset.

This chapter starts with an overview of the data analysis method. For the convenience of the reader, hypotheses scattered in Chapter 3 will be put together. Without too much description, a general procedure of the data analyses will be described in the overview section. It will then go on to examine the five sets of hypotheses in turn.

- *The hypotheses regarding linearity of NPD processes and product newness will be examined first. Then follows*
- *Hypotheses of the parallel level of NPD processes and product newness,*
- *The formality of NPD processes and product newness,*
- *The role flexibility of marketing and product newness, and finally*
- *The role flexibility of R&D and product newness.*

For the convenience of description, the exploratory analysis will not be split from the hypothesis testing. To avoid tedious presentation of statistical figures, the detailed data analysis procedure will be put into appendices.

In the final section, a brief summary of the research findings from the survey will be given. The explanation and discussion of the results, however, will take place in the next chapter, which will be illustrated with the findings from face to face interviews conducted after the survey.

6.1 OVERVIEW OF THE DATA ANALYSIS METHOD

The objectives of this chapter are to test the hypothetical relationships between product newness and NPD processes in the context of British ICT industry and to explore the potential relationships between product newness and NPD processes without prior assumptions. The hypothesised relationships between product newness and NPD processes were described by five sets of hypotheses in Chapter 3. For the convenience of description, they are represented as follows:

- Product newness and the linearity of NPD processes

  The linearity of NPD processes refers to the extent to which the process can be classified as linear, that is, a process with few activities reiterated and almost no feedback. Three hypotheses were proposed regarding the impact of product newness on the linearity of NPD processes:

  H1: Product newness is negatively related to the linearity of the NPD process, that is, the newer the product the less linear the NPD process.

  H1a: The higher the interaction between non-linearity of NPD processes and product newness, the better the performance of the product will be.

  H1b: Other things being equal, reducing the number of design iterations or increasing the linearity of NPD process yields a better performance.

- Product newness and the parallel level of NPD processes

The parallel level of NPD processes refers to the degree to which activities or stages were carried out simultaneously. The three hypotheses proposed regarding the impact of product newness on the parallel level of NPD processes were:

H2 Product newness is negatively related to the degree of overlapping in NPD processes, that is the newer the product, the lower the degree of overlap in NPD processes.

H2a. The higher the interaction between the parallel level and product newness, the better the performance.

H2b. Other things being equal, increasing the level of overlapping yields a better performance.

- Product newness and the formality of NPD processes

The formality of NPD processes refers to the extent to which written rules and documented procedures are followed during the NPD. The three hypotheses regarding the relationship between product newness and formality of NPD processes were:

H3: Product newness is negatively related to the formality of NPD processes.

H3a. The higher the interaction between product newness and the formality of NPD processes, the better the product performance.

H3b. Other things being equal, increasing the formality of NPD process yields a better performance.

- Product newness and role flexibility of marketing

Role flexibility refers to the degree of R&D (technical) activities (e.g. running lab tests) performed by marketing personnel. Two hypotheses were proposed regarding the relationship between product newness and the role flexibility of marketing:

H4a: The newer the product is to the market, the higher the role flexibility of marketing.

H4b: The newer the product is to the technology, the lower the role flexibility of marketing.

- Product newness and role flexibility of R&D

  The role flexibility of R&D refers to the degree of marketing activities (e. g. contacting consumers) by R&D personnel. Two hypotheses were proposed regarding the relationship between product newness and the role flexibility of R&D:

  H5a: The newer the product is to the company, the lower the role flexibility of R&D.

  H5b: The newer the product is to technology, the higher the role flexibility of R&D.

This chapter will go through these hypotheses and examine them using the data collected and explore further on the basis of these hypotheses. The exploratory part of the data analysis was a natural extension on the basis of the verification of these hypotheses. For example, the set of hypotheses regarding product newness and the role flexibility of marketing (H4a and H4b), did not specify how other factors would relate to the role flexibility of marketing. The data analysis will explore the relationship with other factors. As another example of potential exploration, the set of hypotheses regarding product newness and the linearity of the NPD processes (H1, H1a and H1b) did not examine how the interaction between different perspectives of product newness were associated with the linearity of NPD processes. For example, given a product is both new to the technology and to the company, would the NPD processes be linear or non-linear? It is not intended to go through all the possible exploratory alternatives but the above two examples are illustrations of the potential that lies in exploratory analyses.

The major method of data analyses used was simple and multiple regression techniques. An advantage of using regression techniques is that they can be used in investigating both the nature and strength of relationships between two or more variables (Meidan and Moutinho, 1994). Cohen and Cohen (1983) showed convincingly that other analysis methods such as ANOVA or MANOVA can be regarded as special cases of multiple regression. Regression would therefore serve the purpose of analysing the relationships between product newness and

NPD processes both in testing the hypotheses proposed and in exploring further the potential relationships.

For each set of hypotheses, three phases of data analyses were implied: univariate examinations; multiple regression approaches; and effect on performance. These three phases of data analysis are illustrated in Fig. 6.1, which is similar to the graph used in Chapter 3 in illustrating the conceptual framework of the study.

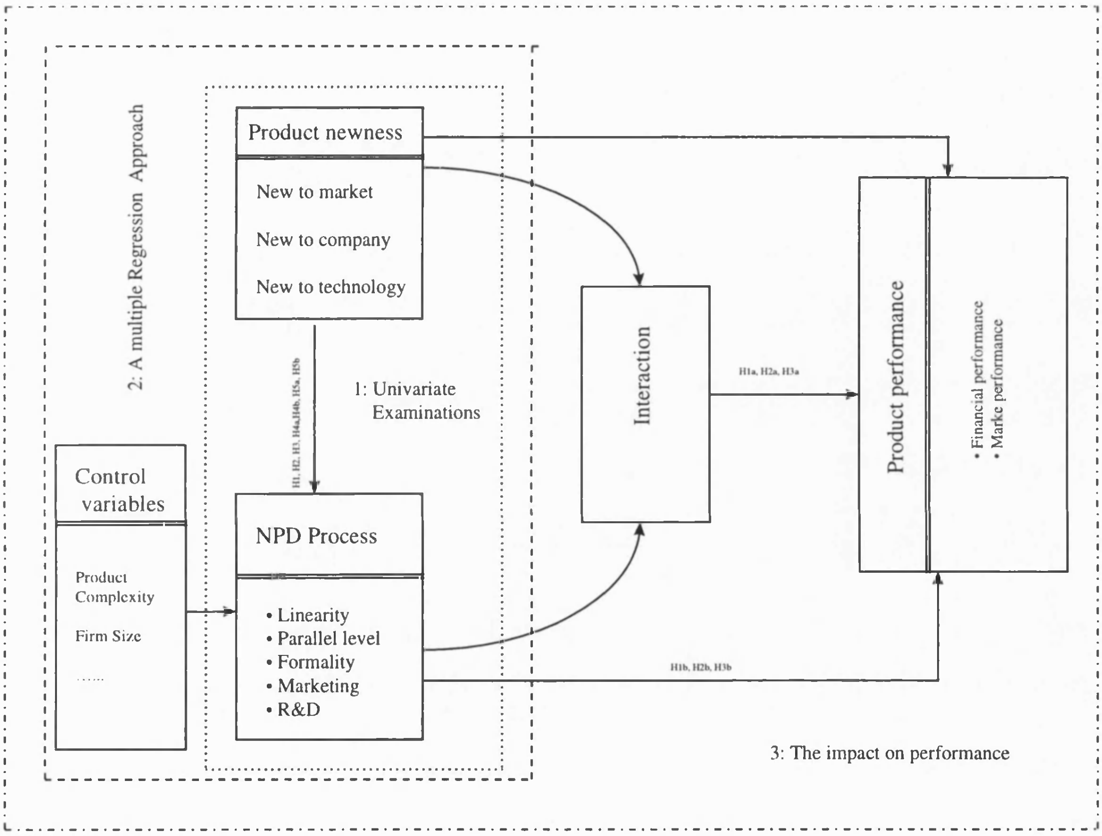

Fig. 6.1 Three perspectives in data analysis

6.1.1 Methods of univariate examinations

First, as it is illustrated in Fig. 6.1, univariate examinations were used to test directly the relationship between each product newness variable (as independent variable) and each NPD process variable (as dependent variable). This included the test of hypotheses H1, H2, H3, H4a, H4b, H5a, and H5b. The mechanism used to test the hypothesis can be described in following equations:

$y=f(x)+e$ (6.1)

Where y can be any of the five NPD process variables

x is any of the three product newness variables (newness to company, newness to market, and newness to technology)

f is a function which could specify the positive or negative trend of x toward y, which depends on the specification of individual hypothesis. The most common form of f, of course, is the linear function

$f(x)=a+bx$ (6.2)

When $b>0$ then the relationship between x and y is positive, while $b<0$ the relationship between y and x is negative.

Considering that in many circumstances the relationship between x and y may not be linear, while it still can show a trend either positive or negative, several other forms of f were considered in the test, especially the following two forms of non-linear relationships: the inverse form and the satisfaction curve This consideration also favoured using equation (6.1) in which only one of the three product newness variables was taken as the independent variable. The joint influence of all of the three product newness variables as a whole was analysed using multiple regression techniques described in the next section.

1) The inverse form

$f(x)=a+b/x$ (6.3)

While $b>0$ the relationship is negative, while $b<0$ the relationship is positive. Compared to a linear trend, the inverse form relationship can provide two kinds of extra information. Suppose $b<0$, then as x increases, f(x) is bounded. While x is small, f(x) can be very small as well. It is suggested that *"If one's weak theory suggests an asymptotic curve, recourse to reciprocalization should be considered (Cohen and Cohen 1983, p264)".*

2) The S-curve

$$f(x)=e^{(b0+b1/x)} \qquad (6.4)$$

While b1<0 the relationship is positive, that is the larger the value x, the larger f(x). A distinct feature of S-curve is that while x is sufficiently large (or near zero), f(x) is becoming constant. While b1>0, the relationship is negative.

Missing values

As indicated in Chapter 5, there were three scales with missing values. The Linearity of NPD processes had one missing value. The parallel level of NPD had 2 missing values. The performance scale had 5 missing values. The treatment of adding dummy variables as it was suggested in Cohen and Cohen (1983) was tried where appropriate. No significant influence was detected. Due to the very small percentage of missing values and for the sake of convenience of description in presenting the results, the dummy variable method recommended by Cohen and Cohen (1983) will not be used here. Instead, common treatment (listwise deletion) was used, which dropped the subjects which had missing values when corresponding variables were involved in the analyses.

6.1.2 Methods of explorations

Secondly, on the basis of direct examinations, the joint influences of product newness variables on NPD process variables were explored. A multiple regression approach was taken, which took the NPD process variable as the dependent variable, the product newness variable and control variables as independent variables.

The exploratory work can be described generally by the following equation:

$$Y=F(X, Z)+e \qquad (6.5)$$

Where X=the set of product newness variables and their higher order form and interactions

Z=the set of control variables (product complexity, types of product, size of the firm, etc.)

F is a linear function of X and Z.

The purpose of the exploratory work was to find to what extent the two sets X and Z can explain Y and to find out variables in X and Z which were significantly related to Y as a whole. According to the protective principle suggested by Cohen and Cohen (1983), if the estimation of (6.5) as a whole was not significant at a certain level say $p<0.05$, then the exploratory analysis would not be carried further on to individual variables in either set X or set Z.

Given the inclusion of the higher order form of variables and their interactions, the problem of multicollinearity would become serious. One solution was to use the centering techniques which have been extensively illustrated by Aiken and West (1991). The techniques in fact are very simple. Instead of using the raw form or standardised form of the independent variables, Aiken and West (1991) suggested that the centering form of the variable should be used. That is, let the transformation be

$$x(\text{centered})=x-\text{mean}(x) \qquad (6.6)$$

Where mean(x) is the average value of variable x in the sample. Where the higher order form of a variable was used, it should be replaced as the higher order form of the centered variable. Where the interaction of two variables is used, the interaction variable should be replaced by the interaction of corresponding centered variables. Using the centering techniques, Aiken and West (1991) proved that 1) it greatly reduced the possibility of multicollinearity 2) the explanation of the regression coefficient became easier and more direct compared to using the raw variable or standardised form of the variable.

6.1.3 Testing the effect on the performance

Thirdly the effect on performance was examined from two perspectives: the effect of interactions (H1a, H2a, H3a) and the effect of process variables (H1b, H2b, H3b).

The effect of process variables (H1b, H2b, H3b) can be tested via techniques similar to those illustrated above with performance variables as the dependent variable, the NPD process variable, and control variables as independent variables.

The effect of interactions (H1a, H2a, H3a) was tested by the comparison of two equations

$$P=f_1(X, Y)+e_1 \qquad (6.7)$$

$$P=f_2(X, Y, X*Y)+e_2 \qquad (6.8)$$

Where X= the set of product newness variables

Y= the set of process variables

X*Y= the set of interactions of X and Y

P= performance variable

The existence of the effect of interactions on performance therefore depends on the comparison of the main effect equation (6.7) and interaction effect equation (6.8).

Note that the difference between (6.8) and (6.7) is that equation (6.8) has an extra interaction item of product newness and NPD process variables. If by adding the interaction items the goodness of fit of equation (6.8) significantly increases then it can be said that the interaction item is a factor which significantly influences the performance. The significance of the interaction items can be tested by recommended formula from Cohen and Cohen (1983) or Jaccard, Turrisi and Wan (1990).

$$F=\frac{(R_2^2-R_1^2)/(k_2-k_1)}{(1-R_2^2)/(N-k_2-1)} \qquad (6.9)$$

Where R_1^2 is the degree of goodness of fit for the main effect equation (6.7), k_1 is the number of independent variables in the equation.

R_2^2 is the degree of goodness of fit for the main effect plus interaction equation (6.8), k_2 is the number of independent variables of the equation. N is the sample size.

In the forthcoming sections, the five sets of hypotheses will be examined in turn. To avoid tedious presentation of statistical figures, only simple regression procedures and the final results of the data analysis are presented. In case they are needed, the detailed data analysis procedures and statistical figures will be provided from Appendix VIII to Appendix XII.

6.2 LINEARITY OF NPD PROCESSES AND PRODUCT NEWNESS

In this section, the relationships between product newness and the linearity of NPD processes will be analysed using data collected. The hypotheses to be examined are H1, H1a and H1b. Hypothesis H1 assumed the existence of a negative relationship between linearity of NPD processes and product newness. It will be tested first, then related issues will be explored further.

6.2.1 A univariate examination

H1. Product newness is negatively related to the linearity of NPD processes. That is, the newer the product the more non-linear the NPD process will be.

The hypothesis was tested using simple regression model with one of the product newness variables (newness to company, newness to market, and newness to technology) as the independent variable and the linearity of NPD processes as the dependent variable. For newness to market, the regression equation used was as follows:

$$\text{Linearity}=a+b*\text{mnew}+e_1 \qquad (6.10)$$

Where Linearity: linearity of NPD processes mnew: product newness to market

The estimated equation was:

$$\text{Linearity}=-4.891194-.247103\text{mnew}+e_1 \quad (6.11)$$

$t=$ (-2.376)

$r=-0.17886$ $N=170$

$F=5.552$ $p=0.0196<0.05$

The relationship between newness to market of the product and the linearity of NPD processes was found to be statistically significant ($p<0.05$).

That is, the higher the newness to market of the product, the lower the linearity of NPD processes. The result showed that new to the market product demanded a learning and probing NPD process in which design iterations and modifications happened.

Similarly, the relationships between the linearity of NPD processes and the other two kinds of product newness were estimated. No significant relationships between the other two newness variables and the linearity of NPD processes were found. The correlation coefficient between product newness to company and linearity of NPD processes was -0.06. The correlation coefficient between product newness to technology and linearity of NPD processes was -.09. Although a negative trend was shown, the relationships were not statistically significant.

In summary Hypotheses H1 was supported in the sense that the linearity of NPD processes was significantly related to the product newness to market. The newer the product is to the market, the more non-linear the NPD process will be.

6.2.2 Multivariate approaches: the exploration

Whereas product newness to market was shown to have significant influence on the linearity of NPD processes and there is no evidence to support the existence of a linear relationship between the linearity of NPD processes and the other two kinds of product newness: newness to company and newness to technology, it is desirable to explore if these product newness variables can influence the linearity of NPD processes jointly. An exploratory analysis was done which used three equations: 1) Joint influence without interaction: putting all product newness variables and their higher order items together but without adding interaction of these variables 2) Joint influence by adding interaction items 3) Considering the effect of other variables. The detailed exploratory procedure is shown in Part A of Appendix VIII. Here only the final results are exhibited.

1) Joint influence without interaction

The result showed that the joint influence of product newness variables can explain 11% of the total variance in linearity of NPD processes. It confirmed again that product newness to market was negatively related to the linearity of NPD processes. While product newness to market was under control, a quadratic relationship between the linearity of NPD processes and product newness to company was found ($p=0.034$). It indicated that both higher value and lower value of product newness to company associated with higher linearity of NPD processes. When product newness to company was near its mean value, its contribution to the linearity of NPD processes reached the lowest point. In other words, given the same level of product newness to market, a U-shaped relationship was detected between product newness to company and the linearity of NPD processes. The nearer the product newness to its mean, the less linear the NPD process was.

2) The interaction between product newness to company and product newness to technology.

Using the testing procedure described in section 6.1.3, the interaction effect of product newness to market and product newness to company on the linearity of NPD processes was statistically significant (p<0.001). The comparison of two models (with and without the interaction item) is shown in Table 6.1. The result showed that if a product was new to a company, the NPD in that company was most likely to adopt a linear, step by step process. The effect was strengthened if while at the same time the product was new to the technology.

Table 6.1 Product newness and linearity (N=170)

Independent variables	Model 1	Model 2	Model 1 vs. Model 2
Product newness to company	0.000	0.007	
Product newness to market	-0.232**	-0.267**	
Product newness to technology	-0.066	-0.035	
The interaction of product newness to technology and product newness to company		-0.314***	
R^2	0.04	0.11	
F			11.72*** [1]

** P<0.05 *** P<0.01

3) The influence of other variables

Further to the estimation of the relationship between product newness variables and the linearity of NPD processes, the possible influence of other factors to the linearity of the NPD process was considered. These influences are: type of products, industry differences, complexity of products, involvement of company to NPD, type of organisation, and size of the company.

[1] The F value was calculated according to equation (6.9).

The result showed that communications technology products manufacturers were more likely to adopt a linear process than computer products manufacturers did ($p<0.01$).

6.2.3 The effect on performance

In this section two other hypotheses H1a and H1b will be tested.

H1a: The higher the interaction between non-linearity of NPD processes and product newness, the better the performance of the product would be.

H1b: Other things being equal, reducing the number of design iterations or increasing the linearity of NPD processes yields a better performance.

In the last section, hypothesis H1 was confirmed in the sense that a relationship between newness to market and the linearity of NPD processes existed. Because there was no evidence to support the existence of the relationship between the linearity of NPD processes and the other two kinds of product newness variables and to avoid the production of too many testing results, hypothesis H1a will only be tested for the interaction of product newness to market and the linearity of NPD processes. That is H1a is rewritten as: the higher the interaction between non-linearity of NPD processes and product newness to market, the better the performance of the product. As the performance of the product can be divided into financial performance and customer performance, the test will be done in turn. First the dependent variable will be financial performance of the product. The testing method is the same hierarchical regression as described in section 6.1.3. A more detailed description can be found in Part B of Appendix VIII.

The results showed that 10% of financial performance can be interpreted by a S-curve of the interaction item between the non-linearity of the NPD process and the market newness of the product. It confirmed hypothesis H1a that the higher the interaction, the better the performance. It suggested, however, that there was a limit beyond which increasing the interaction would not improve the financial performance of the product.

The process of testing hypothesis H1a used above was also useful in carrying out the test for hypothesis H1b. Recall that H1b was stated as: other thing being equal, reducing the number of design iterations yields a better performance. Hypothesis H1b was only partly supported. The results indicated that to a new to market product, increasing the linearity of the NPD process was helpful in improving financial performance of the product. For a not new to market product, however, increasing the linearity of the NPD process did not improve the financial performance of the product. The estimated relationships between non-linearity and financial performance of the product were shown in Fig. 6.2, given product newness to market (M) running from high(5) to low(1).

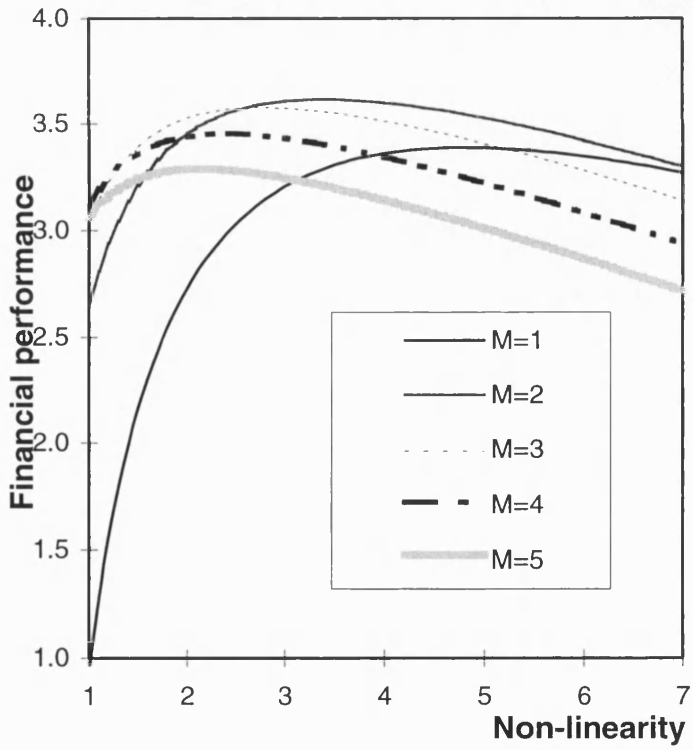

Fig. 6.2 The interaction effect

The result showed that while M (product newness to market) was large, reducing non-linearity of the NPD process yielded a better performance. While M was lower, increasing non-linearity of the NPD process yielded a better performance.

A similar procedure was used when the dependent variable was changed into the customer (market) performance of the product. The interaction effect of linearity of NPD processes and product newness to market on the customer performance of the product was not significant. The result was shown in Table 6.2. As design iterations and re-designs were more directly linked with the cost of development, this result was not unexpected.

Table 6.2 The interaction effect of newness to market of the product and linearity of NPD processes on custermer performance of the product
(N=165)

Independent variables	Custermer performance of the product	
	Without interaction	With interaction
Linearity		-.037(0.867)
market newness of the product	.256*(3.363)	.375 (0.183)
Interaction of linearity and market newness		-.108(.755)
R^2	.066	.067
Sig. F	.004	.011

* P=0.001
The numbers in bracket are t values.

The interaction of linearity and newness to market of the product did not contribute to custermer performance of the product significantly. However, the result did support the proposition that the newer the product to market, the better the customer performance. In the second column of Table 6.2, the regression coefficient of product newness to market is positive (0.256), which is statistically significant (p=0.004<0.01).

In summary, this section examined three hypotheses H1, H1a, and H1b regarding the relationship between product newness and the linearity of NPD processes and its association with product performance. Hypothesis H1 was supported in the sense that the newer the product to market, the more non-linear the NPD process will be. Hypothesis H1a was also supported: it was concluded that the higher the interaction of product newness to market and the linearity of NPD processes, the better the financial performance of the product. Hypothesis H1b was only partly supported, while a product was new to the market, increasing the linearity of the NPD process will improve financial performance of the product.

Further exploration revealed that for a product which was both new to the company and new to the technology, a step by step approach was often chosen by companies. Although hypothesis H1a was supported, the influence of interaction between product newness to market and the linearity of the NPD process on financial performance of the product can be fitted by a satisfactory model. The model confirmed the monotonic increasing trend assumed in hypothesis H1a, but it suggested that if the value of interaction item was sufficiently large or small, it would no longer influence the financial performance of the product. This result was cross validated by further explorations, which concluded that while product newness was high, reducing the number of design iterations would improve the financial performance of the product. While product newness was relatively low, increasing the number of design iteration would improve the financial performance as well.

6.3 THE PARALLEL LEVEL OF NPD PROCESSES AND PRODUCT NEWNESS

Whereas the last section analysed the relationship between the linearity of NPD processes and product newness, this section will analyse the relationship between the parallel level of NPD processes and product newness. The analysis method used in the last section will also imply here. The hypotheses to be examined are H2, H2a, and H2b. Hypothesis H2 described the negative relationship between the parallel level of NPD processes and product newness. It will be tested first.

6.3.1 A univariate examination

H2. Product newness is negatively related to the parallel level of NPD processes. The newer the product, the lower the parallel level of the NPD process.

The testing method used was similar to the one used in testing hypothesis H1. Basically, simple regression models were used with one of the product newness variables (newness to company, newness to market, and newness to technology) as the independent variable and the parallel level of NPD processes as the dependent variable. No significant relationship between the parallel level of NPD processes and product newness to company was found. The correlation coefficient of the two variables was only -0.0053. Neither did the evidence support a statistically significant relationship between the parallel level of NPD processes and product newness to market. The correlation coefficient between the two was 0.0679, which was sufficiently small. A statistically significant relationship, however, was found between product newness to technology and the parallel level of NPD processes. The correlation coefficient was 0.1496, which was significant at $p<0.10$. It should be noted that the sign of the correlation coefficient was positive, which suggested a positive relationship between product newness to technology and the parallel level of NPD processes. The result was in opposite direction with what was expected in the hypothesis H2.

6.3.2 Multivariate approaches: the exploration

An effort was made to test the relationship between the parallel level of NPD processes and all of the product newness variables together. The joint influence without considering interaction was described in following equation:

$$\begin{aligned}\text{Parallel} = &= b0+b1*cnewer+b2*cnewer^2+b3*cnewer^3+b4*mnewer+b5*mnewer^2+b6*mnewer^3 \\ &+b7*tnewer+b8*tnewer^2+b9*tnewer^3 \qquad (6.14)\end{aligned}$$

```
Where cnewer=cnew-mean of cnew: centered value of product newness to
        company
        mnewer=mnew-mean of mnew: centered value of product newness to
        market
        tnewer=tnew-mean of tnew: centered value of product newness to
        technology
```

The initial estimation of equation (6.14), however, showed a non-significant result with squared R =0.04, sig. F=0.61. According to Cohen and Cohen (1983)'s protective principle, due to the insignificance of the F value for the whole set of independent variables, no tests on the set's constituent independent variables are permitted[2]. It was therefore unnecessary to explore further. No significant evidence supported that there was a joint influence of different types of product newness variables on the parallel level of NPD processes.

6.3.3 The effect on performance

Hypothesis H2a and H2b relate product newness and the parallel level of NPD processes to the performance of the product. On the basis of the testing results of hypothesis H2. Only product newness to technology was used in the test.

H2a. The higher the interaction between the parallel level of NPD processes and product newness, the better the performance.

H2b. Other things being equal, increasing the level of overlapping yields a better performance.

The nature of the test was shown in Appendix IX. Hypothesis H2a was supported when the performance variable was the financial performance of the product. The result indicated that the higher the interaction between product newness to technology and the parallel level of the

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[2] See Cohen and Cohen (1983) Section 4.6.4

product, the better the financial performance of the product. Hypothesis H2b was partly supported. The result indicated that given a fixed value of product newness to technology, increasing the level of overlap activities in NPD yielded a better financial performance.

6.4 FORMALITY OF THE NPD PROCESS AND PRODUCT NEWNESS

Whereas issues regarding the linearity and the parallel level of NPD processes were discussed in the last two sections, this section will analyse the relationship between product newness and another attribute of NPD processes: the formality. Following a similar pattern of testing and exploration as that of the last two sections, hypothesis H3, H3a, and H3b will be examined.

6.4.1 A univariate examination

H3. Product newness is negatively related to the formality of NPD processes. That is, the newer the product, the more informal the NPD process will be.

Using similar methods as testing hypothesis H1 and H2 as it was done in the last two sections, no significant linear relationships were found between product newness variables and the formality of the NPD processes. The correlation coefficient between product newness to market and the formality was -0.10. The correlation coefficient between product newness to company and the formality was only 0.01, while the correlation coefficient between product newness to technology and the formality of NPD processes was only -0.07. Therefore the hypothesis was not supported by the empirical data.

6.4.2 A multi-variate approach: further explorations

While H3 was not supported by the empirical evidence, it was desirable to explore further to see if there exist non-linear relationships between product newness variables and the formality of NPD processes. Another important influence variable for the formality of the NPD process is the complexity of products. The more complicated the product development is, the more likely formal NPD processes will be adopted (Griffin, 1997). Industry practice and types of products may influence the formality of NPD processes as well. The detailed exploration procedure is shown in Part A of Appendix X. The result showed that different perspectives of product newness did have different impacts upon the formality of NPD processes and the relationships between product newness and the formality of NPD processes were not linear. First, product newness to technology showed a cubic relationship with the formality of NPD. The relationship showed a monotonic negative trend. It indicated that the newer the product to technology, the more informal the NPD process was. Product newness to company also showed a cubic relationship with the formality of NPD processes. However, the relationship was more complicated. The exploration results showed that at the two extreme points of product newness to company, the trend was as expected. That is, higher product newness to company corresponded to an informal NPD process, lower product newness to company corresponded to a formal NPD process. Nevertheless no conclusion can be reached when product newness to company remained on an average level.

As for other factors, the influence of product complexity on formality of the NPD process was as expected. If the product was internally complicated, that would mean that more people were involved in the development. Then more controls would be enforced and more organisation work would take place. Therefore the process would be more formal. The internal complexity showed a significant positive contribution to the formality of NPD processes (Beta=0.194, $p=0.009<0.01$).

The result also showed that large companies adopted more formal process than small and medium sized companies (Beta=0.155, $p=0.03$). Types of products developed also pay contribution to the formality of NPD processes. Communications products and electronics products adopted more formal NPD processes than computer products (Beta=0.167 p=0.025 for communications technology products and Beta=0.165 p=0.028 for electronics products).

Finally, based on the historical trend, the NPD process was going to be more and more formal in this industry sector(Beta=-.284, p=0.000).

6.4.3 The effect on performance

This section will examine hypothesis H3a and H3b.

H3a. The higher the interaction between product newness and the formality of the NPD process, the better the product performance.

H3b. Other things being equal, increasing the formality of the NPD process yields a better performance.

The testing procedure was shown in Part B of Appendix X. The result did not support H3a and H3b. To understand why H3a and H3b was not supported, further explorations were conducted. The result showed that the contribution of the formality of NPD processes to the financial performance of the product yielded two mutual complemented results. On the one hand, when product newness to company was considered, the contribution of the formality to the financial performance was positive. The effect was strengthened when the product newness to company was high. On the other hand, when product newness to technology was considered, the contribution of the formality of NPD processes was negative. The effect can be ignored when product newness to technology was moderate. The negative effect was stronger when product newness to technology was very high or very low. Therefore the effect of the formality of the NPD process can not be simply treated as positive or negative.

6.4.4 Summary

In summary, there was no evidence to show that there exists a monotonic relationship between product newness and the formality of NPD processes. Nor was there any evidence to show that the formality or the interaction between the formality and product newness related positively or negatively to the performance of the product.

Further explorations, however revealed that a more complicated relationship between product newness and the formality of the NPD process existed. It was found that product newness to company and product newness to technology had a cubic relationship to the formality of NPD processes. It was also found that the role of the formality on product performance was double edged. On one hand, for highly new to company product, it has positive contributions. On the other hand, for highly new to technology product, highly formal NPD process would have strong negative effect on the financial performance of the product.

The results indicated that product complexity is perhaps a more important variable which has a more direct influence on the formality of NPD processes than that of product newness. It was also noted that large companies adopted a more formal NPD process than small or medium sized companies. Types of products also contributed to the differences in the formality of NPD processes.

6.5 ROLE FLEXIBILITY OF MARKETING AND PRODUCT NEWNESS

In this section, two hypotheses H4a and H4b will be examined. Hypothesis H4a describes relationships between the role flexibility of marketing and product newness to market. Hypothesis H4b describes the relationship between the role flexibility of marketing and product newness to technology. These hypotheses were tested using simple regression method as used in previous sections. After the hypotheses were tested, further explanations were conducted which also followed a similar pattern to previous sections.

6.5.1 Univariate examinations

H4a The higher the newness of the product to market, the more flexible the role of marketing plays.

H4b: The newer the product is to the technology, the lower the role flexibility of marketing.

Hypothesis H4a was tested using simple regression with product newness to market as the independent variable and role flexibility of marketing as the dependent variable. The correlation of the two variables was 0.24, which was statistically significant at $p=0.0019<0.01$.

Meeting customer requirements was recognised as the first consideration in shaping NPD in this industry. Understandably, the newer the product to market, the more probing and learning takes place. Reflecting on hypothesis H1, the newer the product to market, the more design iterations take place, therefore there was a need for more feedback from market. It was noted that in the case of new to the market product, marketing personnel have actively participated the NPD process and were responsible for some technical tasks.

Hypothesis H4b was tested in a similar way. The correlation coefficient between product newness to technology and role flexibility of marketing was -.0189. Although it showed a negative trend as expected, it was obviously not significant in the statistical sense. The relationship will be explored further.

6.5.2 The exploration: product newness and role flexibility of marketing

The exploration was divided into two stages 1) joint influence of product newness variables on the role flexibility of marketing without considering control variables 2) Joint influence of product newness variables on the role flexibility of marketing adding control variables. The exploration procedure is shown in appendix XI. Here only the final results are presented.

The exploration results showed that

- A significant positive relationship between product newness to market and role flexibility of marketing existed ($p<0.01$). It again confirmed H5a that the newer the product is to the market, the more flexible the role of marketing.
- A significant negative non-linear relationship (cubic) between product newness to technology and role flexibility of marketing existed ($p<0.05$). This supported hypothesis H4b. It indicated that given the same level of product newness to market, the newer a product was to technology, the less technical tasks marketing personnel took in the NPD processes.
- In addition to product newness variables, internal product complexity contributed positively to the role flexibility of marketing ($p<0.01$). It showed that the more complicated the internal development of a product was, the more flexible role marketing played.
- An increasing trend of role flexibility of marketing was identified. It showed that the role of marketing became more and more flexible in the ICT industry.

6.6 ROLE OF R&D AND NPD PROCESS

In this section, two hypotheses H5a and H5b will be examined in a similar way as H4a and H4b in the last section.

6.6.1 Univariate examinations

H5a. Product newness to company is negatively related to the role flexibility of R&D. That is, the newer the product is to the company, the less likely for R&D people to take marketing's role.

H5b: The newer the product is to technology, the higher the role flexibility of R&D.

Hypothesis H5a was tested via simple regression method with product newness to company as the independent variable, the role flexibility of R&D as the dependent variable. The relationship was significant at $p=0.08<0.10$. The correlation coefficient between product newness to company and the role flexibility of R&D was -0.13, which showed that the newer the product is to company, the less role flexibility of R&D. That supported hypothesis H5a. Hypothesis H5b was tested in a similar way. The correlation coefficient between product newness to technology and the role flexibility of R&D was 0.08, which was not statistically significant.

If a product is new to the company, it can be either new to the market or not new to the market. In the latter case, the manufacturing process or technical know-how existed in other firms may be obtained by various means instead of internal development alone. In the former case, as addressed in H4a, Marketing played an important role including taking over some technical responsibilities. Understandably, if a product is not new to the company, R&D people are familiar with the existing market information and probably have established more contact with customers. It is therefore to their advantage to take some marketing responsibilities.

6.6.2 Product newness and role flexibility of R&D: further explorations

Similar to the last section, the exploration was also divided into two stages: 1) joint influence of product newness variables on the role flexibility of R&D without considering other variables 2) Joint influence of product newness variables on the role flexibility of R&D by adding other variables. The detailed procedure was exhibited in Appendix XII. The result showed that

- A significant negative non-linear relationship (cubic) between product newness to company and the role flexibility of R&D existed($p<0.01$).
- A significant positive non-linear relationship (cubic) between product newness to market and the role flexibility of R&D existed($p<0.05$). It indicated that given the level of product newness to company unchanged, the newer the product was to market, the more flexible role R&D would play.

- A significant positive non-linear relationship (cubic) between product newness to technology and the role flexibility of R&D ($p<0.10$). It indicated that given the level of product newness to company and the level of product newness to the market unchanged, the newer the product is to the technology, the more flexible role R&D would play. Therefore hypothesis H5b was partly supported.
- In addition to the influence of the product newness variables to R&D's role flexibility in the NPD process, the development of communications technology products witnessed less flexible role of R&D than in the development of the other types of products (computer products, and electronics). Two types of organizations stressed the flexible role of R&D in NPD processes. That was wholly UK owned organisations (Beta=0.535, P=0.013) and UK subsidiary of a multi-national (Beta=0.516, P=0.013).

6.7 SUMMARY

Using regression techniques, five sets of hypotheses were tested in this chapter. The examination of hypotheses was complemented by further explorations using the survey data. The results of the data analyses are summarised in Table 6.3, which can be explained from the following five perspectives:

Table 6.3 Summary of data analysis results

NPD processes	Hypotheses	Supported or not	Further explorations
Linearity	H1: Product newness is negatively related to the linearity of NPD process	Partly supported	1. Quadratic relationship between product newness to company and the linearity was found.
	H1a: The higher the interaction between linearity of NPD processes and product newness, the better the performance of the product.	Partly supported	2. Products highly new to company and highly new to technology associated with linear NPD processes.
	H1b: Other things being equal, reducing the number of design iterations or increasing the linearity of NPD process yields better performance.	Not supported	3. While product newness to market was low, increase non-linearity yielded better performance, while product newness to market was high, the opposite was true.
Parallel level	H2: Product newness is negatively related to the degree of overlapping in NPD processes	Contrary results obtained	1. The newer the product to technology, the higher the degree of overlap.
	H2a: The higher the interaction between parallel level and product newness, the better the performance.	Partly supported	2. Given a fixed value of product newness to technology, the higher the level of overlap, the better the financial performance of the product.
	H2b: Other things being equal, increasing the level of overlapping yields a better performance.	Partly supported	
Formality	H3: Product newness is negatively related to the formality of NPD processes.	Not supported	1. Cubic relationship between product newness to company and the formality was found. 2. Cubic relationship between product newness to technology and the formality was found. 3. Significant relationship between internal complexity and the formality was found. 4. Association of the formality and financial performance of products can be neither positive nor negative. 5. NPD processes were going to be more and more formal in the British ICT sector.
	H3a: The higher the interaction between product newness and formality of NPD processes, the better the product performance.	Not supported	
	H3b: Other things being equal, increasing the formality of NPD processes yields a better performance.	Not supported	
Role flexibility of marketing	H4a: The newer the product is to the market, the more flexible role of marketing plays.	Supported	1. Given the same level of product newness to market, the newer a product was to technology, the less technical tasks marketing personnel would take.
	H4b: The newer the product is to the technology, the less flexible role of marketing plays.	Partly supported	2. The role of marketing became more and more flexible. 3. Internal product complexity was positively related to the role flexibility of marketing.
Role flexibility of R&D	H5a: The newer the product is to the company, the less flexible role R&D plays.	Supported	1. Given levels of product newness to market and the level product newness to company unchanged, the newer the product was to technology the more important role R&D Would play. .
	H5b: The newer the product is to technology, the more flexible role R&D plays.	Partly supported	2. The development of communications products witnessed less flexible role of R&D than their peers in the development of other types of products.

- Product newness and linearity of NPD processes

Hypothesis H1 was supported in the sense that the newer the product to market, the more non-linear the NPD process will be. Hypothesis H1a was also supported, it was concluded that the higher the interaction of product newness to market and the linearity of NPD processes, the better the financial performance of the product. Hypothesis H1b was only partly supported, while a product is new to the market, increasing the linearity of the NPD process will improve financial performance of the product.

Further exploration revealed that a product which is both new to the company and new to the technology, a step by step approach was often chosen by companies. Although hypothesis H1a was supported, the influence of the interaction between product newness to the market and the linearity of NPD process on financial performance of the product can be fitted with a satisfactory model. The model confirmed the monotonic increasing trend assumed in hypothesis H1a, but it suggested that if the value of interaction item is sufficiently large or small, it will no longer influence the financial performance of the product. This was cross validated by further exploration, which concluded that while product newness to market was high, reducing the number of design iterations associated positively with the financial performance of the product. While product newness to market was relatively low, increasing the number of design iteration associated positively with the financial performance as well.

- Product newness and the parallel level of NPD processes

Hypothesis H2 was not supported by the empirical evidence. It was found that product newness to technology was positively related to the parallel level of NPD process, while it was expected to have a negative relationship in the original hypothesis. Hypothesis H2a was supported while the performance variable was limited to financial performance of the product. Hypothesis H2b was also partly supported. Given a fixed value of product newness to technology, increasing the level of overlap yielded better financial performance.

- Product newness and formality of NPD processes

There was no evidence to show that there existed a monotonic relationship between product newness and formality of NPD processes. Nor was there any evidence to show that the formality or the interaction between the formality and product newness related positively or negatively to the performance of the product.

Further explorations, however revealed that a more complicated relationship between product newness and the formality of NPD existed. It was found that product newness to the company and product newness to technology has a cubic relationship to the formality of NPD processes. It was also found that the role of the formality on product performance was double edged. On one hand, for highly new to company product, it has positive contributions. On the other hand, for highly new to technology product, a highly formal NPD process would have a strong negative effect on the financial performance of the product.

The results also showed that product complexity was perhaps a more important variable which has a direct influence on the formality of NPD processes than that of product newness. It was also noted that large companies adopted more formal NPD processes than small or medium sized companies. Types of products also contributed to the differences in the formality of NPD processes.

- Product newness and role flexibility of marketing

Hypothesis H4a was supported. A positive relationship was found between product newness to market and the role flexibility of marketing.

Hypothesis H4b was partly supported in the sense that given the same level of product newness to market, it was found that the product newness to technology had a negative association with the role flexibility of marketing.

- Product newness and role flexibility of R&D

  Hypothesis H5a was supported. A negative relationship was found between product newness to company and the role flexibility of R&D.

  Hypothesis H5b was partly supported. Given the same level of product newness to market and product newness to company, a positive association between product newness to technology and role flexibility of R&D was found.

Further explanations and discussions of these results will be presented in the next chapter.

Chapter 7 Product Newness, NPD Processes, and Performance

Whereas the survey data was analysed in the last chapter, this chapter intends to explain and discuss the results of the data analyses. As well reflecting upon how the literature may explain the nature of the data analyses, face to face interviews were conducted to further explore the results.

Managers, who were respondents to the survey from seven companies, were interviewed on a face to face basis. The interviews on average took one to one and a half hours. Evidence and arguments from these post survey interviews will be presented along with discussion of the data analyses.

For the sake of consistency, the discussion of research findings in this chapter will follow the same order as in Chapter 6. This chapter will start with the discussion about the relationship between the linearity of NPD processes and product newness. In each section, a brief summary of the data analysis results will be given. Then rationales behind significant results as well as insignificant results will be examined.

Limitations of the research findings and further research directions will also be highlighted in this chapter.

7.1 PRODUCT NEWNESS, LINEARITY OF NPD PROCESS, AND PERFORMANCE

7.1.1 Summary of research findings

H1: product newness is negatively related to the linearity of NPD processes.

This hypothesis was partly supported by the research findings. In this study three different dimensions of product newness were differentiated, i.e. product newness to market, product newness to company and product newness to technology. It was found that different perspectives of product newness had different impacts upon the linearity of NPD processes. On the one hand, it was found that the newer the product to the market, the more non-linear the NPD process will be. On the other hand, a curvilinear relationship between product newness to company and the linearity of the NPD process was found. That is, both "highly new to company" products and "not new to company" products facilitate a linear NPD process. Whilst "medium new to company" products facilitate a non-linear NPD process. Furthermore, the findings did not support the existence of the relationship between product newness to technology and the linearity of NPD processes.

H1a: The higher the interaction between linearity of NPD processes and product newness, the better the performance of the product would be.

H1b: Other things being equal, reduce the number of design iterations or increasing the linearity of NPD process yields a better performance.

Hypothesis H1a and H1b linked product newness and the linearity of NPD processes to the performance of the product. It was found that the greater the interaction between product newness to market and the linearity of NPD processes, the better the financial performance of the product. The result supported hypothesis H1a, although the relationship between the interaction variable and the financial performance variable was found non-linear. The non-linear relationship followed a pattern of satisfaction curve. That is, when the interaction variable reached a certain point, the financial performance would not be improved significantly. This leads to another research finding which may need some explanation. To different degree of the product newness to market, there is a corresponding point of the linearity of the NPD process at which optimum financial performance can be achieved. It indicated that, for highly new to the market product, those companies who can reduce the number of design iterations achieved better performance; for "not new to the market product", those companies who simply increased the number of design iterations could achieve a better financial performance. The arguments for the research findings will be explained later.

7.1.2 NPD is a learning and probing process

The research findings enhanced the understanding of the impact of product newness upon the linearity of NPD processes from two perspectives: 1) the impacts vary upon different kinds of product newness; 2) the impact can be related to the financial performance of the product.

7.1.2.1 The role of product newness in the learning and probing processes

The first is that the influence of product newness depends on what kind of product newness it is. Among the three perspectives of newness, product newness to market contributes directly to the non-linearity of NPD processes. A possible explanation is that a learning and probing process happens in the NPD process and product newness to market facilitates this learning and probing process. Understandably, if a product is new to the market, new product developers have to learn more about market requirements in order to develop the new product successfully. The process therefore stimulates some kinds of iterations. It was revealed that this iteration happened within the NPD process. This is consistent with Hart and Baker's (1994) multi-convergent model.

At a first glance, it might be surprising to see that the findings did not support that the newer the product to company, the more iterations happened during the NPD process. Because it was reasonable to assume that the newer the product to the company, the less experience the company has, therefore more learning would be needed. That means more trials and errors and hence more iterations should happen. A further probing of these conclusions through the post survey interviews found that companies in the ICT industry may not necessarily go through the learning process when they developed a new to the company product.

Instead, as was the case of the "low product newness to company" product, the "high newness to company" product can also be developed by a highly linear NPD process. The explanation of this result is that although the "experience" which did not exist in the company in the case of a "highly new to company" product, may have existed somewhere in the industry already if the product is not a new to market product. The company can get the "experience" in some way instead of learning and probing again if this learning and probing process proved to be very difficult and not worth going over again. The way of gaining this experience can be through a joint venture, strategic alliance, licensing, and recruiting experienced staff from competitors. It was found that the last method was frequently used in the computer industry. When product newness to company was higher, understandably, as indicated by one of the product manager visited after the data analysis, the NPD process did not necessarily become a non-linear one, because the product might be a "copy" of the existing product:

> *"If you design something new to the market, nobody has ever done it before, so there is very little experience in the industry. If you design something that is new to the company, probably you can get experience in the design of that product from another company, and that's what happens. This product was developed in Austin, Texas. Why do our facility in Austin, Texas develop unix systems? Because IBM, MOTOROLA and other companies have their design facilities in Austin, Taxas. So we can recruit experienced unix people. Our main HQ is in California, why is that? Because that is where a lot of computer expertise is. So if somebody wants to develop something new to them that is already established in the market place, they just recruit people who have experience."*

For a "medium new to company" product, there was no immediate way of 'copying', or it may not have been worth 'copying' directly, and therefore trials and errors would be inevitable during the NPD process. In this sense, a learning and probing process happened, that's why it facilitated a non-linear NPD process. Although learning and probing was necessary in new product development, e.g. it can facilitate a better understanding of the market, and therefore enhance the success of the product, firms have to be prepared to take the risk in the probing and learning process. A successful NPD was a trade-off between the benefit and the cost in probing and learning.

7.1.2.2 The cost of probing and learning process: the moderating role of product newness

The second aspect of understanding is that the influence of product newness on the linearity of the NPD process has an impact on the financial performance of the product. This result is not surprising because design iterations were related directly to development costs. If during the NPD process, one can manage to limit design iterations within individual stages, say maximum design iterations using CAD design, for example, the cost of development will not be increased significantly. If at the trial production stage, an error or flaw was detected, a re-design was required, then the cost would be higher. That, of course, would influence the financial performance of the product.

Furthermore, the relationship between financial performance of the product and the interaction between product newness to market and the linearity of the NPD process was not linear. This complicated relationship was highlighted further in the post survey interviews.

A technical manager expressed his perception on iteration:

"I believe if you have to iterate, you have failed to do this study (pre-development) properly. You should never have to iterate. You should put all of your efforts into getting

the specification correct, then you go to design and development. ... This should happen even in new markets, emerging market like this. You only need to iterate virtually minor point like we did to secure that, something we could not predict from the computer.

We have done lots of market research into what the customers want over the last two or three years. So we are tempted into get it right here first time. If you don't, especially if you are a small or medium size enterprise like ourselves, if we get it wrong, it costs 750,000 pounds to put it into production. That is just for the product. If we look at the other, the actual element(the chip) development, it costs another half a million. If we got that wrong, we could have been bankrupt."

However, it is not always easy to reduce the number of design iterations. Sometimes it is an exercise firms must go through and as a price of learning for a brand new product. A marketing manager in firm G, a large firm with established NPD processes, described this inevitable process:

First he described the initiation of the idea,

"In the computer industry, what we are trying to do in the circumstances of Tandom is trying to differentiate itself through the actual product capabilities. So this machine itself is a differentiated product because it is a fault-tolerant unix machine. There is only one or two other machines like that in the market.

That machine is very interesting. I joined the company six or seven years ago. A week after I joined, I said we needed a more powerful unix system than the fault-tolerant system we launched in Jan. 1990, and that was an innovative machine. And I said we needed something more powerful and a lot of other people said exactly the same thing. That machine is actually the third design. People at our development facility came up with a design and they said this is going to be wonderful. When we were going to have a look at it they got quite a long way down the design process."

Then he described lessons from its first design,

"They went all the way through the design process checks, they got the points when they looked at what the manufacturing cost would be. One said realistically it was sort of sizeable. So they'd written the first document of the market requirement. Now they were

going to the later stage and they found that it was impossible to build at the cost that was being assumed in the original market requirement document. So they then stopped, because it was not going to meet market requirements".

In the second design, new problems appeared:

"In a recent design, we tried a completely different approach. Without going to technical details, instead of building a system where you have lots of processes that all plug in the same machine, we wanted to build a system of clustered unix machines... We established a standard for clustered systems. When the moment we came to be re-evaluate it, we found that, no, that would not actually work. So that was why we actually came to the third design and this was four years ago. Again we got quite a long way down the road".

The third design was much better, but new problems were still on the way:

"And they realised that there is a problem, that we've been on our own. We've been virtually the only company with the software architecture. and we would find it very difficult to find software port to the machine. To be successful in the unix market place, you must have lots software on that. So one of the criteria was that we should get lots of software on that."

In order to solve the problem, the company built a strategic alliance with another big computer company. Eventually the product was a great success. The example showed that learning and probing is a process that the company has to go through when developing a new to the market product even for a company whose NPD process may be well-established, whereas there is no denying to say that the "lucky innovator" may exist (Jin, Birks, and Targett 1996).

These evidences indicated further that the role of non-linearity of the NPD process is double-edged. On the one hand, higher non-linearity of the NPD process means higher cost and higher risks in the sense that the project might not be commercially viable. On the other hand, higher non-linearity facilitates a learning procedure in the NPD process, and thus design iterations and modifications of the original design are inevitable in the case where new to market products are developed. Using design iterations properly can speed up the NPD process (Eisenhardt and Tabrizi 1995). A simple logic behind this is that when one goes over the process again, one can be much faster than the previous time and get a better result because each iteration or change is based upon the experience gained in previous experiments (Arrow, 1962). Putting these two together, it can well explain the results: other things being equal, lower the degree of non-linearity in the case of new to the market product can yield a better financial performance. While in the case of "not new to market" product, increase the level of non-linearity can yield a better financial performance. The premise before this rationale is, of course, to keep a positive trade-off between the benefit and cost of non-linear NPD processes.

7.1.3 Learning and unlearning: in and out the new product development process

Lynn, Morone and Paulson (1996) observed that

> *"Probing and learning is an iterative process. The firms enter an initial market with an early version of the product, learn from experience, modify the product and marketing based on what they learned, and then try again. Development of a discontinuous innovation becomes a process of successive approximation, probing and learning again and again, each time striving to take a step closer to a winning combination of product and market."*

This research extended their observation by confirming that the probing and learning happened within the NPD process for new to the market products. Product newness to market was identified in this study as a key determinant in the iteration of the NPD process. In contrast to their optimistic attitude toward probing and learning, it was suggested here that one has to pay for the iteration of NPD development. While the cases described in Lynn, Morone and Paulson (1996) are all giant enterprises, this study suggested small and medium enterprises (SME) may not be able to afford such a luxury in probing and learning. A manager in a medium sized electronic firm admitted frankly, if the product they were working on failed, they could be bankrupt before they got the "experience" to learn again. Lack of funding in R&D in SME is another factor to deter this probing and learning process, which in turn deters the development of really new to the world products.

Kleinschmidt and Cooper (1991) suggested that innovativeness is both a negative factor and a positive factor to the success of NPD. This research extended their study by revealing how product newness may influence NPD processes. According to Kleinschmidt and Cooper (1991), low innovative and highly innovative products have higher success rates than moderately innovative products. Therefore they contended that managers should treat moderately innovative products with more caution. This study confirmed that more iteration happened in moderately new to company products than both high newness to company products and low newness to company products. The explanation from this study therefore matches the findings of Kleinschmidt and Cooper (1991).

Zaltman et al (1973) suggested that the more radical an innovation, the more learning and unlearning must take place, and therefore the greater modification must be made in existing structure and processes. This study confirmed their argument and further pointed out that the learning and unlearning process happened when developing a new to the market product.

Although this study was a cross sectional study, it can illustrate in some perspective the learning and unlearning process when firms develop a family of products. The reason behind this is that product newness for each individual product was measured in this study, which provided a continuum from highly new products to merely modifications of existing products that can be regarded as equivalent as considering a family of continuous new products. For example, Burgelman and Maidique (1988) proposed a model of new product success and failure in which successes and failures alternate with irregular rhythm. They suggested:

"In the model, a sequence of success is followed by either a major organizational change, changes in organizational design, technology, or market direction that prompt an economic failure, which in turn spurs a new learning pattern". (p 334)

An important phenomenon described in their model was that firms often turned success into failure by believing that repeating past practices would reproduce past successes. The findings in this study suggested that with a brand new product firms may get success. But when they make greater modifications to an existing product (a medium new product to the firm), more learning and unlearning was required than the development of previous one. But that is a point many firms often ignored and refused to give more attention because this time they were developing a "medium new to the company" product instead of "highly new to company" product of previous time. It is easy to be complacent and more optimistic due to the success of the first product. Hence it is not a surprise to understand a failure waiting ahead. Just as Burgelman and Maidique (1988) commented,

"Success can breed failure for firms that continue to view the future through the prism of present victory, especially in the dynamic industry environment".

To the finding of this study, it is this "newness trap" which turned firms from previous success to next failure.

7.1.4 Limitations related to findings

It must be pointed out that the findings of this study are limited by the way the linearity of NPD processes was measured. As it was explained in Chapter 4, the measurement was based on the NPD model constructed in Chapter 2. It measured explicitly modifications and iteration activities across four stages in the NPD process: idea, concept, prototype, and product in trial. The advantages of using this scale were obvious such as easy to understand, measurement items easy to follow, easy to replicate etc. On the other hand, one disadvantage of this measurement is that it can not measure activities within each individual stage. For example, during the concept stage, many alternatives may be tried again and again without returning back to the idea stage or forward to make a prototype. In other circumstances, the development of the product concept might be very simple or straightforward. The linearity scale did not measure explicitly these differences.

A further consideration specifically relevant to the research into the linearity of NPD processes was that the over-all study was set at the level of individual NPD projects. A new to the world product may be developed through the effort of several generations of evolution in the sense of manufacturing process, marketing, and technology. The iteration may happen across different product generations. These non-linear NPD processes were ignored in the design of this research. For example, a NPD process might be completely linear, while its product failed to market, therefore another NPD process was embarked upon and the procedure iterated to a larger extent until final success of the product or sadly, the trial and error procedure stopped somewhere. This common design limitation of surveys may call for more complicated research designs which, instead of using individual projects as the research unit, should use the family of product evolution as the research unit, that is, a combination of historical analyses and cross sectional survey design.

7.2 PRODUCT NEWNESS, OVERLAP OF NPD PROCESSES, AND PERFORMANCE

7.2.1 Summary of research findings

H2 Product newness is negatively related to the degree of overlapping in the NPD process

Hypothesis H2 was not supported by the research findings. Product newness was again described in three aspects: product newness to market, product newness to company, and product newness to technology. The findings revealed that product newness to technology was positively related to the parallel level of NPD processes. That is, the newer the product to technology, the higher the degree of over-lap of NPD processes. The relationship disclosed was in the opposite direction to what was assumed in the hypothesis.

The findings did not support the existence of the impact of the other two kinds of product newness on the parallel level of NPD processes. That is, there is no evidence to show that parallel level of NPD process was associated with product newness to company or product newness to market.

H2a. The higher the interaction between the parallel level and product newness, the better the performance.

H2b. Other things being equal, increasing the level of overlapping yields a better performance.

Hypothesis H2a and H2b linked product newness and the linearity of the NPD process to the performance of the product. It was revealed that given a fixed value of product newness to technology, there existed a positive relationship between the parallel level and the financial performance of NPD processes. That finding supported hypothesis H2b: other things being equal, the higher the degree of overlapping, the better the financial performance of the new product. The interaction between the parallel level of the NPD process and product newness to technology was also found to be positively associated to the financial performance of products. This result supported Hypothesis H2a. Combining these two results together, it was suggested that other things being equal the higher the degree of overlapping of NPD activities, the better the financial performance of the product. The effect is stronger, when product newness to technology is higher.

7.2.2 Motivation behind the concurrent approach

It had been expected that the newer the product, the lower the extent of parallel level in the NPD process. Achieving higher levels of overlapping have been identified as one of the major means of speeding up NPD. Past research found that to use this tactic successfully, firms must have a certain degree of familiarity with the technology embodied in the development, readiness of the market that is to be targeted, and there must be less uncertainty in the development. That is an environment likely suited for incremental innovations (Eisenhardt and Tabrizi 1995, Cordero 1991). The contrary result showed that it is necessary to rethink that rationale. Firstly, it might be true that parallel activities can be best realised for incremental innovation, but it was not necessary for every incremental innovation to adopt such an approach unless there was a necessity to make this approach possible. The adoption of such an approach depends on opportunity cost, the pressure the development team had, the atmosphere or the culture of the firm, and the skills the development team have to drive a parallel process.

Secondly, from after survey interviews, it was found that a number of practices support the research findings, that is the newer the product to technology, the higher the degree of parallel activities in the NPD process. One of the reasons was that in the case of higher product newness to technology, uncertainty was increased at the same time, therefore there was a need to develop some kind of "prototype" as early as possible. In the case while at the same time the product was not new to the market, it was more than likely that the prototypes appeared even before the concept. Based on the prototypes of the product, further probing in the manufacturing process was developed. Therefore the increase in the degree of overlap may greatly reduce the high uncertainty as it was suggested in Terwiesch, Loch, and Niederkofler (1996):

> *"Instead of following a sequential phase by phase process, design-built-test loops are used as a learning facility. A project then experiences a highly non-linear and iterative process which relies heavily on experiencing product performance based on testing. Observing the*

test results gives then feedback to the engineers yielding learning opportunities and uncertainty reduction.(p696)"

A taxonomy of the computer system development process by a product manager in the post-survey interview revealed a rationale behind this result.

"Certainly within the process, you would be developing prototypes. So for example, if you are building a new computer systems, like s4000, what you have to build is hardware and software, so there would certainly be a process where you build some hardware, some prototype hardware which was for software people to use to improve their software. I think in that sense it is going to be overlap. In the sense that if all you do is to develop software on an existing hardware base, the process would start at a particular point where you design your software now, and start to improve it on the hardware. You actually introduce some extra steps I guess, because you improve your software as best as you can on the early hardware and you have to re-test it when you get the final hardware. Obviously what you want it to do is to get the product into the market as quickly as possible. So where it is a complete system with new hardware then, you would involve manufacturing people quite early because if you don't, you could find that you cannot build it to the cost you assumed in your market requirement documents."

A technical manager in a communications firm commented:

"You got more concurrent engineering with completely new technology because you are not quite sure how the technology works. Some of you would go down one route while the other would try slightly different route around."

In summary, use of concurrent engineering was seen as a tool to speed up NPD and to get better product quality. A key variable in concurrent engineering was the degree of overlap between different activities. This study provided evidence to support such an approach in the sense that while a product was newer to technology, higher degree of overlap was required. This view extended other researcher's findings that parallel processing should be realised in a low product uncertainty environment. The potential implication is therefore while developing a new to technology product, managers should be aware that the use of overlap activities is necessary to facilitate the NPD processes.

7.2.3 Limitation of research findings

This study did not address other variables which may directly influence the over-lap of NPD activities such as opportunity cost, pressure for innovation. A direct outcome of the concurrent approach may be a cut of development time instead of improving the financial performance of the product. The former was not explicitly explored in this study. These consideration may constitute factors which influence the strength of the results.

7. 3 PRODUCT NEWNESS, FORMALITY OF NPD PROCESSES, AND PERFORMANCE

7.3.1 Summary of research findings

H3: product newness is negatively related to the formality of NPD processes.

This hypothesis was not supported. A further exploration showed nonlinear relationships between product newness and the formality of NPD processes. It also revealed that the internal complexity of products related positively to the formality of NPD processes. That is, the more complex a product is, the more formal the NPD process would be. The study also found that large firms used a more formal NPD process than small and medium firms.

H3a: The higher the interaction between product newness and the formality of NPD process, the better the product performance.

H3b: Other things being equal, increasing the formality of NPD processes yields better performance.

Hypothesis H3a and H3b were not supported by the research findings. A further exploration revealed a complicated interaction effect of product newness and the formality of the NPD process on the financial performance of the product. On the one hand it was found that the formality of NPD processes contributed to the financial performance of new products positively when product newness to company was higher. On the other hand, it was found that formality contributed to the financial performance of the product negatively, the effect was stronger when product newness to technology reached its two extremes. This result showed that the role of formality in the NPD process was double edged. It can facilitate the NPD process and it may also detract the performance of the product.

7.3.2 Why insignificant relationships?

Intuitively, as some managers in the after-survey interviews believed, highly innovative products should be linked with an informal NPD process, low innovative products should be linked with a formal NPD process. The majority of the 171 NPD processes surveyed in this study, however, were claimed to be more or less formal NPD processes(The mean value of formality was 3.85 on a five point Likert scale with 1 represents the informal end and 5 the formal end, standard deviation=0.73). This phenomenon might be industry specific. Large software development, for example, usually follows a formal procedure as specified by the principle in software engineering. The fear for failure and the belief that a formal process can improve the quality of new products, also leads to the adoption of formal NPD processes. As claimed by a technical manager in a software house: " *we develop software products, quality is very important, if there is a failure, it could be very expensive*". The intensive competition and fear for failure made NPD processes more and more formal in recent years. Millman (1986) suggested: " *there is a great need to adopt formal procedures for dealing with complexity and uncertainty*".

The reasons behind the non-significant relationship between product newness and the formality of the NPD process were further highlighted by interviews with product managers. One of the reasons is that a formal process was regarded as an effective mean of organizing. The technical manager in a software house explained why he used a formal approach on a very "new" product.

"That is partly because the way we do things some background that might be useful. We are principally a software house so we develop bespoke software systems for other companies. We have about 200 staff and 15 million turnover. We develop software products but I should say the quality is very important for the particular sector of business---high integrity, real time software system. So it is the system where there is a failure that things go wrong very quickly. It could be very expensive. So we develop high quality software systems. The products we develop were byproducts of our business in that you could not run a service company like GIL[1] on 100% utilization of staff. You tend to have 85% to 90% utilization of staff, with 10 to 15% of the staff being not on a particular job at any time but being on between jobs. That means a quite large pool of labor at one time that can be used to something else. We use our pool of that labor to develop our software test product-- the product we were talking about. Because you got a large turnover and that pool of people of labor, you could not possibly develop product unless you were very formal about the method you used. So that is the reason that product was very formal about that process, yet being a fairly new technology is used."

Further interviews showed that the reason revealed here is not uncommon. The marketing manager in a large computer firm argued for formal process they used:

"We operate certainly things like that developments and they are all within a framework where we have a very very rigid structure. So for us it is actually very important that the steps are adhered to. Because we know that if you tried to breach those steps, that might affect the product quality at the end of the day. So maybe we are the exception. I think all the companies should worry about quality. Even if you know that you got the process that works, you should be actually even more rigorous about the process because there are many more uncertainty when introducing a new product. You should not be allowing yourself to move on and go outside the process because you just increasing the risk."

The research findings here did not support the empirical findings in Olson, Walker and Ruekert (1995) who reported a study in investigating the relationship between the type of new products and types of co-ordination mechanism employed in NPD process. They found a strong relationship between product experience(newness) and co-ordination mechanisms. Formalization was suggested as one of the main structural attributes of the co-ordination mechanism. The relationship between formalization attribute and co-ordination mechanism is shown in Fig. 7.1.

According to Olson, Walker and Ruekert (1995), as one moves from bureaucratic control toward more organic and participate structures (from up to down in Figure 7.1), rules and operating procedures are less formalized and less rigidly enforced. That is, formalization varies from high to low as the co-ordination mechanism move from top to bottom. They concluded that now that product experience was highly related to the co-ordination mechanism, the product experience variable must relate to the formalization attribute in the same way.

Figure 7.1 A continuum of interfunctional co-ordination mechanisms[2]

Types of co-ordination mechanisms	**Formality**
Bureaucratic Control	High; More reliance on Rules and standard procedure
Individual Liaisons	↕
Temporary Task Forces	
Integrating Managers	
Matrix Structures	
Design Teams	
Design Centres	Low; Fewer rules and standard procedures

[1] Fake name of the company
[2] From Olson, Walker, and Ruekert (1995) P50 Figure 1.

According to Olson et al (1995), while a product was new to the company, project control should be released. In contrast, some managers tended to impose control when product newness was higher. An experienced technical manager, who developed numerous successful new products in the past, explained his rationale of the "tight control"

> *"I will try to ensure that the newer the product is, the more novel idea in it, the closer on it people work together, the more frequently we have meetings. (If) They understand the market, the product in the market place in addition to our product range, then the controls can be relaxed because the people know so well what they are doing. When they have got a completely new product on this issue, we have to pool people to work together. The electronic designer does what he wants to do. And you get the software guys, then you find you can not write software to meet the requirement because your RAM is not sufficient. ... Yeah, the newer the product, the stronger the control. And you have to spend more time on communication between the people, the members of the team. We have weekly meetings. On that "Me Too" product, we probably had meetings of this intensity of every 2 or 3 weeks. We do have the major project reviews, project meeting. we do have (meeting) every probably 5 to 6 weeks. On this (really new product) we had (meetings) only (every) 2 or 3 weeks. People always think they know more than they do. They overestimate how well they understood, the characteristics. 'Oh I know everything the electronic guys want'. On the "Me Too" product, that is probably right, or more likely to be right. For completely new product, they still think, oh well, I know what they need. And they are more likely to be wrong. So you have to make them aware, you have to spend more time, a big percentage of hours per week is devoted to communication."*

Furthermore, another explanation of the inconsistency of the research findings from Olson at al's discovery can be obtained by underlining the difference in the learning mechanism of the ICT industry revealed in this study from that of Olson et al's conceptual framework. According to Olson et al (1995), it was inferred that the newer a product is to the company, the less experience the company have and therefore the more difficult the development of the project. The higher difficulty of the project development requires higher interdependence of resources.

The higher interdependence of resources demanded more frequent resources flows. That leads to less formalness of the co-ordination mechanisms.

It is true that the newer the product is to the company, the less experience the company have in developing the product. However, from the learning mechanism revealed in this study (Section 7.1), that the difficulty of the development of the new product project may not necessarily vary according to the level of experience the company has or alternatively the product newness to the company. In the case where a product is new to the company, they may not develop the product purely on their own. The company may copy the experience by various means, which can greatly reduce the level of difficulty and therefore the risk involved. By so doing it is necessary for the company to maintain a relative formal process!

7.3.3 Establishing a formal NPD process

While non-significant results abound, the first reaction was to check the measurement scales. As indicated in Chapter 5, no flaw in the measurements were found. In order to find out why non-significant results were achieved, four respondents were visited. Among them there were two respondents who reported higher product newness while reaching a very high degree of formality during NPD. All respondents accepted that theoretically they agree with the contingency view of NPD (That is an informal NPD process is suitable for radical product, a formal NPD process is suitable for an incremental product). Realistically, however, they prefer to use a formal NPD process. Reasons behind this were

1. Formal NPD process is an assurance of quality
2. Formal NPD process was regarded as a means to reduce risk and uncertainty.
3. Formal NPD process was regarded as a way of realising stronger control.

This was echoed in Moenaert and Souder's (1990) findings. They summarised their findings from 10 interviews of 6 Belgian companies.

"Most respondents blamed the lack of formal rules and procedures regarding the interaction between marketing and R&D for the inadequate information transfer between these two functions,..., The formalization of the new product development process through design review boards, milestone reports and scheduled meetings creates discussion forums that leave ample opportunity for raising and screening new and challenging ideas. The formalization of innovative activities not only results in an increase of formal communication, but stimulates informal communications as well. ... Formalization structures the flow of information. The formalization of interfuctional communication puts a lower bound on the amount of information exchanged during the planning stage, and an upper bound on the amount of information exchanged during the development stage.(p222)"

In their later research, Moenaert and Souder et al (1994) contended that project formalization relates positively to the commercial success of product innovation projects, although the correlation they found was not strong ($r=0.20$, one tail $p<0.10$).

To conclude, the research findings reflected two contrary views on the NPD process. One view was that there exists a best model for NPD, using this formal model or formal process, one could achieve a better NPD performance. This view was widely accepted by managers visited after the survey. It was also reflected in the survey result. As stated earlier, the average formality index of the NPD process was as high as 3.85 on a 5 point Likert scale (SD=0.73). Higher formality of the NPD process was believed to be a guarantee of higher quality of the new product and therefore a success. In fact when the product was newer, managers tended to impose stronger control to reduce the risk and uncertainty. The other view was that the formality of the NPD process should vary according to product newness. Formal NPD processes cannot always guarantee a better product performance. This view was reflected in the exploratory part of the data analysis that the formality can be associated positively or negatively with the financial performance of the product depends on different perspectives of product newness. The dual role of the formality is worth further exploration in future research.

Other influence factors

The influence of product complexity on NPD processes was as expected. If the product is internally complicated, that means more people are involved in the development, then more controls are enforced and more organisation work takes place. Therefore the process would be more formal. A manager in a large company explained why his small group of people used an informal approach.

> *"We are working usually on 4 or 5 projects simultaneously. The need for a certain amount of informality of the processes is essential. We have to have that, an underlying project program which we can use as guideline, which is the critical part for project plan. The way that people interact with each other is very very informal. Individuals know their responsibilities. It is very much, I mean, it is an advantage to have this small group. People work very closely with each other and have stronger control. They come together as a group when needed. They also meet in ones twos or three's as necessary as a very regular constant process. And we also have a very good bulletin board and a conference system where all of that team know that if, for instance , people are out or traveling abroad or whatever they can still continue."*

The result suggested that product complexity might be a more important factor in regard of the formality of NPD processes. In a most recent study, Griffin (1997) concluded that '*overall, the more complex a product, the more time a formal process eliminates from the development cycle*'. Therefore the effect of using a formal process for a complicated product and using an informal process for a less complex product is worth further investigation.

Understandably, large companies adopted more formal processes than small and medium sized companies. A marketing manager in a large computer company explained this clearly:

> *"Certainly we do have a very formal process. We are a large company and the way we were set up is that when there is something new a new division is set up. That product the S---400, was developed by a division, and that division operated almost like a start up*

company. But it is constrained, although it has its own ideas, by the formality of the main company which says we know that if you are going to be successful then you must make sure these procedures are adhered to. You do those things and those steps as you produce new products. While as a small company, they probably do not have those procedures established. So the first time they develop a product they will do things perhaps in strange orders. The next product they develop they realise they made mistakes. If they did it in different order it might be better. When you get to tens of products, then you have a very rigid process to implement. We develop hundreds of products at the moment. Hardware products have a certain procedure to proceed through, software products have a procedure to proceed through. A complete system product has a procedure to go through, those stages product managers know about, we do not see them in detail. But they will have specific stages to go through."

Types of products developed also pay contribute to the formality of NPD processes. Communications products and electronics products adopted more formal NPD processes than computer products. A vice president in an established large company, which is facing the challenge of digitalisation, explained how difficult it is to set up a formal NPD:

"Because we find that, (even we are working today with, and after all we are still dependent on, should we say, a technology partnership which will be arranged with other suppliers which may be the hardware in Taiwan or whatever), even within their project plan, the nature of industry is so dynamic that the changes in development have been so fast that their ability to really formalize their projects is not there. They struggle, too, to stay up with the market requirements and therefore the process is constantly one of the iteration. You establish your fundamental project concept and then you find you are in the process of continuous change as you move through various stages of constant iteration and therefore it is very difficult to get up a very formalized project plan."

In summary, establishing a formal process was regarded as a means to reduce risk and uncertainty and a way to guarantee better quality of the product. That's probably one of the reasons no significant relationships were found between product newness and the formality of NPD processes. However, there was no direct evidence to support that a formal process would guarantee the success of products. Explorations in this study suggested that the role of formality might be double-edged. Further investigation was still necessary. The formality of NPD processes was seen as associated with the internal complexity of product. This study suggested that the more complex a product, the more formal NPD process would be.

7.4 PRODUCT NEWNESS, ROLE FLEXIBILITY OF MARKETING AND R&D

7.4.1 Product newness and role flexibility of marketing

H4a: The newer the product is to the market, the more flexible role of marketing plays.

H4b: The newer the product is to the technology, the less flexible role of marketing plays.

Hypothesis H4a was supported by the survey data . That is, the newer the product to market, the more flexible role marketing played.

Hypothesis H4b was only partly supported. It was found that given the same level of product newness to market, the newer a product was to technology, the less technical tasks marketing would take in the NPD process.

The results can be explained further from three perspectives. First, it is essential for marketing people to know the technology in high tech settings. This was echoed in findings in the literature. A person in product marketing for a computer company stated:

> *"Some marketing people have credibility in engineering. First it tends to be people that understand the products and technology... Second it helps to be fortunate enough to do things engineering recognises as being useful... My credibility comes from talking technical without looking like an idiot (Workman, 1993 p413)."*

The same phenomena was observed in this study. An engineering manager in a large switch board company stated :

"I would say all of the marketing people in our company have an engineering background. I doubt there are any commercial marketing people just purely commercial. Many of our commercial people who sell have also engineering or application experience. When you have a representative from a firm to come in and to show you the products, you will not waste an hour with an individual who has only the ability to deliver a leaflet. You need to talk about specifications, what the product will do and will not do. And people who can only deliver specifications only stay here two minutes. And they are gone. It's better to give the letter to the postman and the postman deliver the letter he knows nothing about the product. There were years in this country, people sold the products with very little product training. I did not think nowadays you can sell a product with such a poor mechanism. When you get to the high-tech products, you need people who understand the product, the application of the product, and mis-application of the product, which is just important. Because the end user, the end specification is looking at this information. If you have not got the right people in your organization, to supply this data, to the specified end user, you are not going to get your product crossed."

Secondly, the newer the product to market the more likely marketing people have a better grasp of technology than other people in the organazation. The marketing people usually are among the first in exploring the possibility of developing a new to the market product in the organization. With their technical advantage, they then put insight into new product specifications. They are perhaps more familiar than R&D or engineering about the potential product features. This superior position let them play a very important role in later development and their knowledge about the market and technology enables them to perform some relevant tasks. The engineering manager recalled the development process of a new to market product:

"When we went into electronics, programmable controllers, the marketing people were one year ahead of everybody else because it was driven by a market survey and they had experience on the competitors products. They could programme, they could do this. Engineering was formed and recruited to join in one year later. So marketing people maintained a form of supremacy because of their knowledge no one else in the

organization had. We started off with no knowledge, marketing with one year experience ahead of us.

So a new product to a new market, I would say yes. Marketing are possibly the only people who would be happy with in-depth experience because of the way they have been structured. It's because, probably, they have been getting involved in doing a survey of competitors, of hands on experience."

On the other side, it is natural to notice that the newer the product is to technology, the less flexible role of marketing would play. This could be because marketing people are more likely to concentrate upon market needs instead of technology solutions. It may also be beyond marketing's capability to attack advanced technology problems. This differentiation between R&D and marketing may eliminate the worry of project responsibility fuzziness conjectured by Moenaert et al (1994).

Thirdly the finding extended Anderson's constituency view of marketing. Derived from resource dependent theory, Anderson (1982) argued that

"*The marketing concept is essentially a state of mind or world view that recognises that firms survive to the extent that they meet the real needs of their customer coalition* (p23)".

While Anderson (1982) suggested that marketing represented the interests of its customer constituency, this study extended this view one step further. It was suggested that in high tech settings the customers were usually well equipped with technology knowledge, the marketing person as a representative of them should also be equipped with relevant technology. By doing so it would also be beneficial to the product specification and the communication and understanding between marketing and other project development team members. So it was natural that the higher the role flexibility of marketing the better the customer performance of the product. As suggested by Anderson (1982) 15 years ago

"Marketing's objective, therefore, remains long run customer support through consumer satisfaction. Paradoxically, perhaps, this approach requires marketers to have an even greater grasp of the technologies, perspectives and limitations of the other functional areas. p24".

7.4.2 Product newness and role flexibility of R&D

H5a: The newer the product is to the company, the less role flexibility R&D plays.
H5b: The newer the product is to technology, the greater role flexibility R&D plays.

Firstly, hypothesis H5a was supported by this study. It was found that R&D people have more power about marketing matters in NPD when the product was not completely new to the company. Secondly, hypothesis H5b was supported in the sense that given the same levels of product newness to market and product newness to company, the newer the product was to technology, the more important role R&D would play in the NPD process.

Although the necessity of cross-functional skills of innovation personnel has often been stressed in the literature (Gupta and Wilemon 1990, Griffin and Hauser 1996), it is still very hard to be realised (giving differences in existing organizational culture for example, (Moenaert et al 1994)). Contrary views were raised over the role flexibility of R&D personnel. On the one hand, R&D, engineers and technologists were regarded as highly 'profession' oriented. They wanted to pursue technology as a career and they were going to lose momentum if they took other responsibilities such as sales and other commercial activities. It was just not effective to cross those career tracks (Avishai and Taylor 1989). On the other hand, it was argued that one can not really understand the market unless the technologists get involved with customers in a deep and sustained way. Sales force played the role of opening the door and finding the opportunities which was not enough to solve the customer's problems (Taylor 1990). In this study, it was revealed that both views might be held in certain circumstances because different kinds of products demanded different levels of the role flexibility of R&D. For a new to the market product, a higher level of role flexibility of R&D was required (Appendix XII). That is R&D personnel should get involved in marketing activities while developing a new to the market product. It was also found in this study that marketing personnel performed more R&D activities in developing a new to market product. Combining these two findings together, it was not difficult to see that for a new to market product, both R&D and marketing need to have a deeper understanding of each other's work. That is, a new to market product demanded a higher level of integration between R&D and Marketing.

As to product newness to company, it was found that the newer the product to company, the lower the degree of role flexibility of R&D in the NPD process. In other words, if a product was not new to the company, R&D personnel may participate in more marketing activities. This may be explained by the time orientation theory of Lawrence and Lorsch (1969) and professional orientation theory of Miller and Wager (1971). According to Lawrence and Lorsch (1969), R&D managers often have long term orientation, while marketing managers have a shorter perspective. According to Miller and Wager (1971), the professional orientation was defined as the individual's desire to be involved in the larger network of professional relations that cuts across organizations. Individuals with professional orientation initiate and retain their identification with their professional group. Because the long term commitment of R&D personnel, with the disappearance of the product newness to company, R&D personnel became more and more familiar with the product category and the market. At the same time due to the shorter time orientation of marketing personnel, it was sometimes inevitable for R&D personnel to take over some marketing activities in the development of products they were familiar with, whilst marketing personnel may be new to the company themselves. Note how a product manager described this phenomenon:

> *"It's again because of the difference on the people's discipline, because if it is an established product and it is just the delivery of it, then there is a lot of (market) knowledge in engineering, in development, in R&D. The engineer will have a lot to say of the product because he has lived with the other generation of the product being involved with the*

project, he probably tried some of the ideas before and if you look at the marketing organization, there is less stability in the individuals. Individuals in marketing come and individuals go. In engineering, it is not here anyway, we do not change so quickly. Marketing people in the last two years, I guess we have seen 50% new faces in the marketing area. I would say probably some of these people would not be here two years time. They are moving on. In engineering you see people moving on within the discipline. You see people getting more senior but staying in the discipline. Marketing people seem to be people who are moving."

7.4.3 Managerial implications

The results suggested that while designing a portfolio of new products, professional orientation and capability of R&D/Marketing to take extra-functional tasks should be considered. Emphasis should be put, while developing a new to market product for example, on not only marketing personnel's business acuteness but also his/her capability and in-depth knowledge in carrying out technical tasks. It was in this general background which can nurture and produce the so called powerful 'top person' or the genius 'other person' (Langrish et al 1972) or 'product champions' in NPD. In the case of new to the market product, the integration of tasks and role changes between marketing and R&D may happen which inevitably raise the problem of responsibility fuzziness. It is certainly an interesting topic to discuss the borderline between marketing and R&D in carrying out extra-functional activities while addressing the integration between marketing and R&D.

The association of product newness with role flexibility of R&D/marketing also suggests that the knowledge background and professional orientations of R&D and marketing was very important in deciding the nature of NPD development. In high tech settings, it would be difficult to imagine a new to the world product that can be initiated and carried out by a person who was not aware of the technology content of the product.

7.5 SUMMARY

It was concluded that the impact of product newness on NPD processes were multi-dimensional. The three perspectives of product newness, newness to market, newness to company, and newness to technology, were found to be associated with five attributes of NPD processes.

Product newness to company was seen as a factor relating to the role flexibility of R&D, the less new a product is to a company, the more active role of R&D personnel in carrying out marketing responsibilities.

Product newness to technology was seen as a factor relating to the parallel level of NPD processes. The newer a product is to the technology, the higher the degree of overlap of NPD activities. Given the same level of product newness to market, it was concluded that the newer the product is to technology, the less role flexibility of marketing would have.

Product newness to market has also had an influence on the role flexibility played by marketing. It was concluded that the newer the product to market, the more technical tasks marketing would play in the NPD processes. The development of new to market product required closer integration of R&D/marketing and mutual penetration of responsibilities. It was worthwhile to classify to what degree such penetration between R&D/marketing can be reached in the development of a new to market product in high tech settings.

Product newness to the market was seen as a major factor relating to the linearity of NPD processes. It motivated a learning and probing process, which should be treated with caution. On the one hand, to a new to market product, the learning and probing process was not only necessary but also inevitable. Learning and probing may speed up the NPD process, quickly approaching customers' requirements via continuous iterations and feedbacks. On the other hand, one must be aware that the cost of such a probing and learning process was high. Pre-development studies, CAD techniques were important to reduce unnecessary design iterations and modifications. Further research was called for in determining what kinds of iterations were inevitable and what kind iterations were avoidable. The question became in what circumstances can iterations be managed in a cost-effective way?

Reflecting back on the methodologies used in this research, a qualitative enquiry before the postal survey may have been helpful in refining the set of hypotheses and stronger results may have emerged. For example, the hypotheses regarding the relationship between product newness and the formality of NPD processes may be changed, provided sufficient insight can be obtained from the fieldwork in advance that may give different views from Olson et al's (1995) empirical results. However, it should be pointed out that there is no guarantee of getting more 'significant' and 'stronger' results by conducting depth interviews before a postal survey. In other words, the research, being 'new' to the researcher and new in the research area, is a probing and learning process in itself and conducting depth interviews does not necessarily make that process more straightforward. Indeed, as it is shown in this chapter, some insignificant results obtained in the data analysis yielded deeper understanding and more explorations than statistically significant results. Backward regressions used in the exploration procedure, for example, picked up significant cubic terms and filtered out linear and quadratic terms. Verifying the role of these cubic terms remains an interesting topic for further research.

Chapter 8 Conclusions

It was concluded that the impact of product newness on NPD processes can not be ignored. This finding extended current understanding of product newness. It was the first research to suggest different perspectives of product newness had different impacts on NPD processes. The study found that product newness to market was associated positively with the non-linearity of the NPD process, that is, the newer the product to market, the more non-linear the NPD process would be. To put it further, the more non-linear the NPD processes, the more frequent design iterations and feedback and modifications, therefore the more intensive the probing and learning will be. On the one hand, this probing and learning process was inevitable. It can facilitate the product development in the direction of producing a product which can meet or be expected to meet customer requirements. For example, the use of customer test or Computer Aided Design (CAD) or Beta site may all trigger iterations and modifications which aim at a better version of the product. On the other hand, it takes risks and costs to carry out such a probing and learning process although the costs and risks for different learning activities (e.g. customer test and CAD) may vary. On the basis of the research findings, it was concluded that for a "not new to market" product, merely increasing the non-linearity of NPD process could yield a better product performance. While to a "highly new to market" product, reducing the degree of non-linearity of NPD processes would yield a better product performance. The result suggested that in developing a "not new to market" product firms seem to be paying less attention to the feedback signal during NPD processes, while such information in fact is very important in reducing the cost or adding values to the product. In developing a "new to market" product, on the other hand, if the feedback signals had been identified earlier, the degree of nonlinearity would be reduced and the development costs could be lowered.

The above findings are helpful in highlighting the puzzlement from observations of Languish et al (1972) some twenty five years ago:

> "*Market information undoubtedly played a valuable part in directing R&D into useful channels. Some reservations must, however, now be entered. One such reservation concerns the value of formal market research carried out by independent organisations. We have encountered some cynicism about this. ... A major limitation of the idea that innovation should be planned in advance to meet clearly specified market objectives is the observed fact that the successful innovation often emerges from activities whose principle objectives at an earlier stage were not those that in the end met.(p52-53)*"

The study suggested that a NPD process is basically a learning and probing process which indicates the newer the product to the market, the more possible the '*clear specified market objectives*' be modified because the ultimate objective is getting success other than meeting planned market objectives. Thus, managers must be prepared to modify or change their initial market objectives while NPD is carried out. Product newness can be served as one of the indicators in relation to the extent the initial market plans need to be changed.

Whereas iterations and feedbacks indicate one kind of learning and probing, overlapping of activities provides another form of probing and learning whereby different routes to the same solutions were tried simultaneously. It was concluded that for a "new to technology" product, a certain degree of overlap of activities in the NPD process was required. This finding supported the application of concurrent engineering whereby a "new to technology" product was developed. In those circumstances, a higher degree of overlap of NPD activities facilitated the performance of the product.

These two forms of learning and probing were important in differentiating different perspectives of product newness. In the case of a "new to market" product, the probing and learning was basically an iterative, trial and error process, which stressed the nature of approximation and probing in maximising knowledge of customer requirements (which perhaps was very vague before the development of the product). In the case of a "new to technology" product, the probing and learning may be aimed at implementation or realising the known or relatively clarified customer demand, different ways were often tried in parallel. The parallel activities can speed up the process and at the same time identify suitable ways to provide problem solutions whereby iterations may or may not happen during this process.

Furthermore, in a high tech setting like the ICT sector, this study suggested that product newness to market was positively associated with the role flexibility of marketing. This means that marketing people must have in-depth technical knowledge and be able to carry out a certain number of technical tasks while developing a "new to market" product. On the other hand, it was also found that product newness to company was negatively related to the role flexibility of R&D. That is, while a product was less new to the company, R&D personnel would take part in more marketing oriented activities.

The results therefore suggested that different combinations of role flexibility of marketing /R&D may be moderated by product newness. While past literature addressed the importance of integration between R&D and marketing, this study suggested differentiation of the role of marketing and R&D was equally important.

About 10% of products surveyed in this study were claimed as 'new to the world' products. By linking product newness to attributes of NPD processes, this study provided a bridge of research into continuous and discontinuous innovations. Its revelation of the learning mechanism complemented and extended Lynn, Morone and Paulson (1996)'s theory of probing and learning which was built from the observation of so called 'discontinuous innovations'. On the basis of the research findings, this study suggested that the learning mechanism differs in NPD if different perspectives of product newness applied. The finding is therefore important for further research as a basis in understanding how to utilise the learning mechanism in NPD to get a better performance.

The research findings were helpful to practitioners in at least three perspectives:

First this study provided a basis for using the learning mechanism in the NPD process. In designing their strategy of NPD, managers should be aware that a "new to market" product requires an iterative NPD process, in which learning may happen to a large extent. The iterative process may not only happen from **concepts** back to **ideas**, it may well happen backwards from **prototypes** to **ideas** or from the **product in trial** back to **ideas**. While for a "new to technology" product, the learning mechanism may well be a parallel process. Building such an awareness of differences of learning in NPD was helpful in planning in advance to avoid delays or to predict possible delays. For example, a company was visited which was developed "new to technology" products. They used to carry out well-prepared pre-development studies such as market investigation to avoid costly iterations. The technical director claimed that one should never allow iteration to happen. His confidence was built on numerous successes of development of incremental products. While in the context of a "new to market" product, without enough awareness of possible iteration, it would cause problems. The company happened to identify a need for a "completely new to market" product recently. It was in panic while unanticipated changes after the prototype stage happened. The launch had already been delayed three months when the company was visited. If the company had built such an awareness of learning in advance, they might have been more successful.

Secondly, in carrying out NPD processes, managers should pay special attention to feedback signals. These feedback signals may be helpful in speeding up the development process or adding value to the new product being developed by means of more accurately reflecting customer demands. Even if sufficient pre-development study is done, ignoring feedback signals during the NPD process would still be dangerous. In case product newness to market is involved, adhering to the planned programme without changes according to the feedback signals may imply a larger extent of design iterations and possibly the product would fail to meet the market demand.

Thirdly, the study is helpful in assisting managers to build an awareness of product newness in differentiating the role flexibility of R&D/marketing. If the role flexibility of marketing is not high, the idea of a "new to market" product may be less likely to originate from marketing personnel because of their lack of technical knowledge. Therefore it is difficult for them to take ideas a step further.

This study is useful to academics in the NPD area in following perspectives.

(i) The NPD process model proposed in this study can be served as a platform for NPD researchers in this area. NPD processes are conceptually complicated and difficult to articulate. In past, various models of NPD processes have been proposed for the purpose of achieving the best performance if the model is properly followed. In this study, a NPD process was abstracted as a layered model. First, The NPD process was regarded as a **probing and learning** process, which transformed the most primitive form of the product (an idea, for example) to a form which can be accepted in the market. These different product forms (i.e. ideas, concepts, prototypes, products in trial, products launched) have been widely recognised and covered in most of the NPD process models in the literature (e.g. Cooper 1986). However, it is only in the model proposed in this research that the transition of different product forms being made explicit and linked to the learning mechanism of NPD. This in turn is helpful to academics who contrast experimental NPD processes and rationalised NPD processes (Lynn et al 1996, Cooper 1986). Secondly, The model is not only useful in analysing new product development processes of individual firms, but also useful in the case of the intra-firm new product development (networks, collaboration, strategic alliance, and supplier chain management). The novelty of proposing an entity layer and a relationship layer lies in that it combines the E-R model in computer science with the research results from the NPD literature and that makes the model a powerful tool to be used by academics in NPD research area.

(ii) The 'newness' construct used in this research extends current understanding on the issue and provides rich opportunities for future research. This research showed that 'newness' is a subjective but important concept which should not be ignored. On the basis of past research (Kleinschmidt and Cooper 1991, Booz Allen & Hamilton 1982, Johnson & Jones 1957, and Robertson 1967), this study considered 'newness' in multiple dimensions and 'newness' was not being considered as isolated categories but on a continuum of variables. Burgelman and Maidique (1988) proposed a similar cubic model (new to technology, new to company, and new to market). But it was only in this research that the multi-dimensionality of the product newness construct being examined by empirical data. By looking at 'newness' from the three distinct perspectives, NPD researchers can find new opportunities for future research. One of the possible approach can be simply relating the 'newness' construct to the layered model of NPD processes.

An interesting topic derived from the research findings of this study, for example, is the necessity of understanding further the learning mechanism in NPD processes, especially the distinction of different kinds of learning and their impact on the development process. Probing and learning is an inevitable process while developing a "new to market" product. It is desirable to know what can be learned and probed in advance and what must be learned during the NPD process. This includes, for example, identifying different feedback signals in NPD processes. There is no denying that pre-development study can reduce the risk of NPD. However, the pre-development studies are only the first step in identifying feedback signals. For a "new to market" product, pre-development studies are not enough because the marketing plan may keep changing during the development process. NPD is a continuous probing and learning process which reduces the uncertainty of the development and the risks involved. Identifying feedback signals earlier is certainly helpful to reduce the development risks. An important direction for future study is therefore to gain a better understanding of feedback signals and the learning mechanism in NPD. For example, how should those feedback signals be used to develop new products effectively. By so doing it can certainly maximise the effect of learning and minimise the cost. It is believed that once the problem of learning in NPD is solved, one can say that the 'black box' of NPD processes can be completely unpacked.

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Appendix I To Be Objective in Conducting Marketing Research: Myth or Reality?

It goes without saying that seeking the real truth is the ultimate goal every honest scientist holds. The marketing researcher is no exception. There has been a long time debate as to whether this goal can be achieved. The early debate seemed to reach the conclusion that social science is subjective, while the modern debate has made further attacks on the problem that all science is subjective (Hunt 1993). As for marketing research, it is not difficult to find from the research procedure that almost every step of the marketing research could be regarded as a struggle against subjectivity and bias in some sense. So it is quite reasonable and helpful to argue to what extent can we achieve our goals. And to be objective in conducting marketing research, is it a dream or a reality?

Marketing research, in the first instance, is "*to provide information that will assist marketing managers in recognising and reacting to marketing opportunity and problems*" (Tull et al, 1987). Can we really know the market, the consumer, the marketing opportunity and problems by conducting marketing research? This question may be traced back to a bigger question of what we can really know about the world surrounding us. Again two different opinions arise. Lee (1982) suggested that what we learn is not the world but particular codes into which it has been structured so that we may 'share' the experience of it. The point is along with Sapir (1949) who held the view that the real world is to a large extent built up on the language habits of the group. Conducting in consumer research, Holman (1981) put this view clearer that "*cultures incorporate different perceptions of the time in the verb structure of their language and there is, culture-specific image of the future may affect investment and buying patterns perceived risks in buyer behaviour and buyer-seller interaction across culture borders.*" This may suggest that the language of a culture determines the reality that members of that culture see and therefore it is impossible to reach objectivity in conducting marketing research as the research is surrounded by the culture environment and limited by the language used. The design of questionnaire, for example, may be regarded as half science and half art. It is quite possible that the designer may bring his or her perceptions or even potential bias into the questionnaire and that different respondents may have totally a different understanding of the same question asked even if they belong to the same cultural background let alone different cultural environment. According to Mick (1986), consumer's behaviour is based on the meanings they ascribe to marketplace stimuli. The defender of objectivity in marketing research, however, holds a different point of view to this argument. Hunt (1993) points out that the language of a culture determines the reality its members see is simply not true. He quotes an example test about the perception of colour. The language of a culture may to some extent describe the reality that member of that culture sees, but not largely determines the reality. Otherwise it is unreasonable to explain the common point in discovery of science among different cultures.

Apart from the language barrier of certain cultural background, the paradigm which the researcher falls in is another area that the debate carries on. The second argument in favour of the impossibility to be objective in conducting marketing research owed its origin to Kuhn (1962) and Feyeraband (1975). In his influential work in 1962, Kuhn pointed out that the paradigms that researchers hold are incommensurable. This means that every researcher is circumscribed by his own paradigm and therefore the search for reality would be inevitably limited by that and objectivity is all but impossible to realise. However, this is not a great threat to the objectivity of marketing research, as argued by Hunt (1993), "*it is easy to find different paradigms in marketing if one uses a suitable loose interpretations of the word 'paradigm' but no one has yet put forth different paradigm that (1) make conflict knowledge claims and (2) are in any meaningful sense incommensurable (objective choice is impossible)*". This argument is only partly supported by Hudson and Ozanne (1988). In their works on consumer research, a weak but not strong incommensurability were revealed existence between different approaches in consumer research. They examined the difference and conflicts in general research process, data-gathering techniques and criteria used by different approach. Positivist and interpretative approaches are distinguished. As marketing research is in its young age (Bass 1993), how do we know strong incommensurable paradigms will not be appear in future?

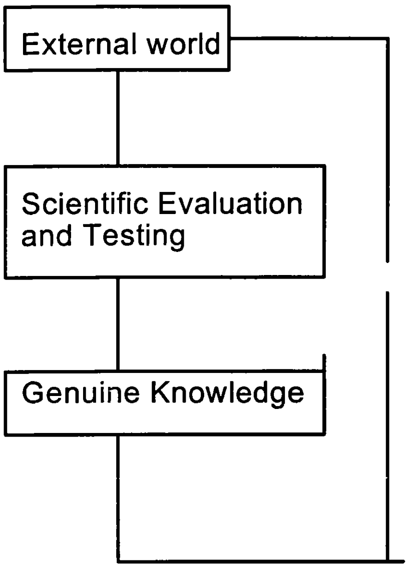
This turns to be a well developed argument in past literature that theories are often undermined by facts. Yesterday's "objective" theory or truth may be recognised false today just because we found "facts" that are contrary to the recognised theory. So no objectivity exists only that our mental interpretation of reality improved (Peter 1992 and Kuhn 1962). On the other side, after comparison of historical investigation and the practice of marketing, Nevett (1991) pointed out that the marketers may hold the same view as most historians: a reasonable approximation of objectivity can be reached by the subjectivity as well as by the objective route. "*It is unwise, therefore, for the marketer to equate 'subjective' with biased*" and so to assume it to be inferior to 'objective fact'. Though more difficult to work with "subjective fact" can still yield objective conclusions. Hunt (1990, 1993) argue even more directly that facts may not undermine theory in marketing research. By quoting Bunge's metaphor (1967), he developed his scientific realistic view that the empirical process in marketing research can be objective (Hunt, 1992) but that such objectivity can also be compromised. He insisted that "*the community of marketing research can provide its clients with no more than a reasoned 'weighing' of the evidence. As fiduciary agents, we should provide no less*".

As to what we can provide or even what we could observe, Mick (1986) and Kuhn (1962) pointed out that the psychology of perception informs us that no theory-free observation language is possible. Observations and surveys in marketing research are no doubt under the influence of "certain theory", that is, by the mental interpretation of reality, and therefore result in the impossibility of objectivity. Furthermore, all epistemological significant observations are theory-laden. For example, even the terms used in the research are assumption taking. Hudson and Ozanne (1988) pointed out that labels used by different approach exemplify different assumptions about the research relationship. "*In the laboratory experiment a person under investigation is called the subject and effort is made to maintain a separation between the research and the subject... In the close-ended survey, the individual is called the respondent, a term presupposing that the research knows the best question to ask in order to discover a phenomenon....*". That is, "*the methodology is consistent with the theory, and the theory supports the methodology.*" In contrary to this, Harre (1986) argues that epistemic value is a belief-selecting mechanism. In his words, "*simple truth is, all things considered, what is most rational believe, in the context of right action*". After analysing the research procedure of marketing research, Hunt (1992), on the other side argued that the perception of observations can be guaranteed by measurement theories that are properly applied. He reached the conclusion that science practice can be objective and, thus can produce objective knowledge although absolute objectivity can not be assured because of uncertainty.

To put it briefly, there are two completely different attitudes about the issue of objectivity in conducting marketing research. One is negative and the other is positive. Both seem to hold good reason for their point of view. We need to explore the problem a little bit further. At the heart of the problem is the term objectivity. We may well ask the question what is objectivity and how can we say we are being objective or subjective? It seems a very simple question but it is, in fact, a rather complicated issue. Different paradigms (empirism, postempirism, relativism constructivism, critical theory, positivism, for example) hold different definitions of objectivity and subjectivity. For the definition of objectivity is closely related to the issue of whether or not knowable truth exists. Due to the limitation of this small essay we can not attack this problem in-depth. To understand the diversity of this situation, Megill (1994) in his *Rethinking of Objectivity* classified four senses of objectivity---absolute, disciplinary, procedural and dialectical.

Megill contended that in much of the twentieth century philosophical discussion, it is generally agreed that absolute conception of reality cannot be reached. Absolute objectivity, then present itself as absolute not in its certitude of infallibility but rather in the hold that it ought to have on us as rational beings. It is in this sense, scientific realism (Hunt 1993) insists about the possibility of objectivity in conducting marketing research, as Peter (1992) briefly illustrated in figure 1. This point of view was strongly argued by many others in literature as we have summarised above. We will, however, see a slight compromise on the following sense of objectivity.

The disciplinary sense of objectivity, defined institutionally, "*refers to the claim by practitioners of a particular discipline to have authoritative jurisdiction over its area of competence. Such claims take different forms, with different degree of explicitness and articulation. The groundings vary from discipline to discipline and from field to field, and they change over time as well (Megill 1994)*". It is in this sense of objectivity that a compromise is achieved for the possibility of objectivity in conducting marketing research. No strong conflicts between different paradigms in marketing research (Hunt 1993, Hudson and Ozanne 1988) means that a generally authoritative view within marketing research might be possibly achieved and therefore disciplinary objectivity is of great possibility to be reached. It is interesting to notice Peter's (1992) illustration about relativism or a constructionism view of reality as shown in figure 2. One cannot reach the uninterpreted reality but one can improve oneself within the disciplinary or research field so that usefulness can be strengthened.



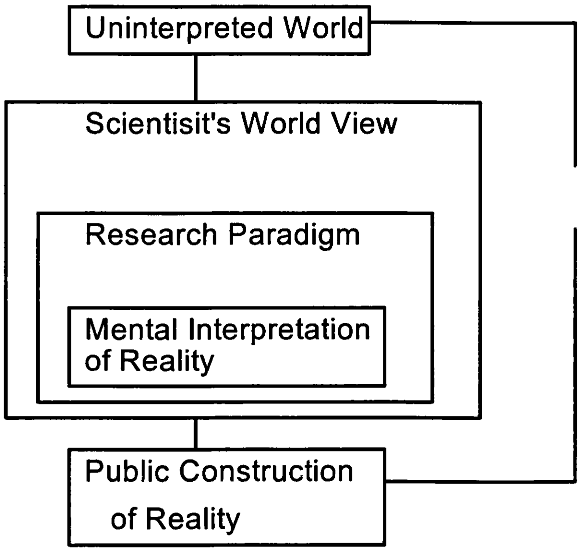


Fig. 1 Scientific realism's view of reality **Fig.2 Relativistic/constructonist view of reality**

Furthermore, we can often find analogous examples in science (especially in marketing research) where "truth" is replaced by the "procedurally correct". Researchers often stress that they have followed impersonal procedures (random sampling, for example, in marketing research) without claim that the procedure guarantees the truth of their findings (Porter 1994). It is in this sense that we could say researchers reached the procedural objectivity, although empiricists may cherish the hope that the neutrality of methodology would guarantee the interpretation of absolute reality. The procedures or sets of rules are in fact playing the role of narrowing the play of subjectivity. In a situation where values are in conflict and consensus elusive, this may well be the only choice.

Last but not least, the three senses of objectivity above all assume that objectivity is contrary to subjectivity, while dialectical objectivity, in contrast, "*involves a positive attitude toward subjectivity (Megill 1994)*". Subjectivity plays an indispensable role in the constitution of objects. In this sense, according to Fabian (1994), objectivity will be regarded as the result of a knowledge production process rather than a virtue of individual researchers or as a property of methods or logical models. Knowledge production involves the making of objects. To construct rational beings, absolute objectivity may even been seen as a particular case of dialectical objectivity. In fact dialectical objectivity could be regarded as a generalisation of the other three senses of objectivity. Here further exploration of the issue is beyond the scope of our work.

To better summarize, the reach of objectivity in conducting marketing research is not a myth but a long way to across. We illustrate the situation in Figure 3. It is highly possible for marketers conducting marketing research to reach procedural or disciplinary objectivity. The reaching of absolute objectivity would be a much more difficult task, although it is not in any sense completely impossible. And subjectivity will play an important role in the construction of objects.

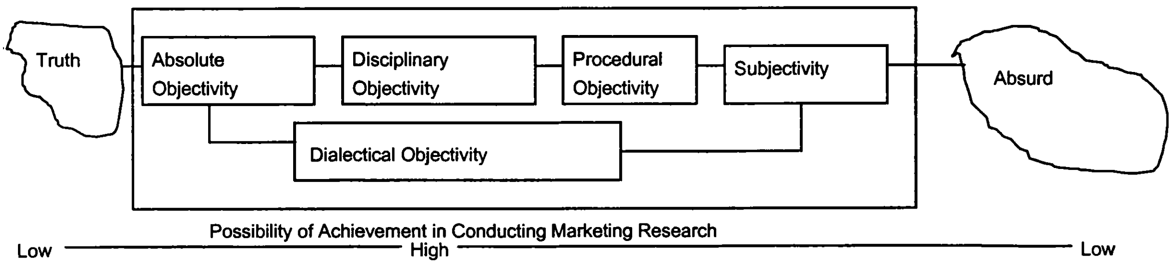


Figure 3 Conducting Marketing Research and Objectivity

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Appendix II The Multi-case Study: A Secondary Data Approach[1]

ABSTRACT

Instead of attempting to find a generic solution to improve new product development (NPD) performance, this paper explores contingent approaches to effective NPD. A modified repertory grid analysis technique is used to analyse 30 new product cases, all the development processes of which are identified as effective. The result yields six different approaches which adhere to different contexts. It therefore suggests that there is no unique way to achieve effective NPD. Managers should react differently according to the contexts the NPD is engaged in. Although not comprehensive, the research results may serve as a guide to effective NPD in relevant contexts.

INTRODUCTION

Although various solutions to "best practice" or "silver bullets" have been found recently, many authors tend to agree that there does not really exist a universal solution that is suitable to all cases (Calantone, Di Benedetto, and Haggblom, 1995). A number of reasons may contribute to this argument.

First, there is no consistent way to measure the outcome (success or failure) of NPD and there is naturally no universal way to achieve it. Research on the success and failure of NPD has been booming in recent decades and many factors have been found to be critical to the success of new products (Craig and Hart 1992). Griffin and Page (1995) suggested,

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[1] The main content of this appendix has been presented at the 3rd International Product Development Conference held at INSEAD, 1996, co-authored by David Birks and David Targett.

"However, even with all the research which has been done in this area, it is difficult for a firm to define whether in fact a new product is successful. Using the result from previous research published on measuring success and failure as an aid in determining the 'best' measures is confusing".

At the heart of the problem is the multi-dimensional nature of product development performances (Hart 1993, Cooper and Kleinschmidt 1995). More than 75 distinctive measures of success have been used by firms and academics with little or no consensus across either group (Griffin and Page 1995).

Secondly, it is almost impossible to get excellent performance in all the distinctive measures of success simultaneously (Griffin and Page 1995). That is, the product development process which yields success in every perspective does not exist. In fact, the NPD process itself is a process of learning, a process of trials and errors accompanied by many uncertain factors (Zaltman, Duncan and Holbek 1973). There is, therefore, no guarantee that the learning process will be perfect in every perspective.

Being aware of the fact that there might be no generic solution to improve NPD performance, this study intends to explore ways of effective NPD in different situations. By effective product development we mean that the outcome of the development processes yields good performance in the major dimensions to measure product success. According to Griffin and Page (1993), when measuring a project's level of success, outcome can be qualified along three independent dimensions: consumer-based success, financial success, and technical or process-based success. An effective NPD refers to one that yields excellent performance in at least one of the three dimensions.

The key research question is: **what is the relationship between an effective NPD process and its context?**

CONTEXTS AND PROCESSES

Every new product is developed within a particular context which may have a strong influence on the choice of processes to be developed. Abdul Ali (1994) concluded that the nature of product development is influenced by firm or industry characteristics, marketing characteristics, and innovation characteristics. Firm or industry characteristics include structure variables like size, entry barrier, incumbent market leader, and behaviour variables such as entry timing and licensing. Marketing characteristics include technology variables (such as opportunity and sequence of innovation) , and competition variables (rivalry) and customer variables (adoption).

The survey by Booz Allen & Hamilton (1982) revealed that a formal and often inflexible new product process is most closely associated with developing a new product that is closely linked to existing businesses. While a less restrictive approach is associated with developing new-to-the world products.

In a broader sense, Miller and Blais (1993) pointed out, the modes of innovation, refer to the repertoires of behaviours that firms employ to adapt to, match or transform their environment in order to gain competitive advantages, vary from industry to industry . They showed that there exist stable patterns of modes of innovation, such as the science-based product innovation mode, the entrepreneurial fast-track experimentation mode, the global cost leadership mode, the reactive mode of reliance on technology and process adoption, across different industrial sectors. This may suggest that there is a fit between effective NPD and its context.

Olson. Walker and Ruekert (1995) addressed this issue partly but more directly. They revealed a fit between the degree of formalness of co-ordination mechanism and the experience level that firms have. The latter is, of course, inversely related to the degree of product newness. The main conclusion is that the less experience the firm and the marketplace have with a new product concept, the more organic and participative the co-ordination mechanism used to manage the product development process. Fitness between the firm's experience level and the co-ordination mechanism, could yield better performance, that is evaluated in financial success, timing and personal psychological satisfaction levels of project participants. The degree of innovativeness or newness of the product being developed is identified as an important moderator of the impact of different co-ordination structures on the development process and its outcomes. Despite its 'best practice' orientation, the flexibility of NPD processes is also addressed in Cooper and Kleinschmidt (1995).

Based on the above analysis, the following assumption is formed:

Assumption: *Effective new product development is characterised by a proper match between NPD processes and the contexts in which NPD is involved.*

A number of research results tend to support this assumption (Shrivastava and Souder 1987, Duncan 1976). This paper does not intend to test the assumption directly. What we are concerned with is a more practical side of this assumption, that is, exploring how the processes are matched with the contexts in effective NPD. This might be useful to practitioners who are surrounded with numerous "best practice" guides. As suggested by Krubasik (1988), "*too often, managers respond with the same development strategy without considering the context in which they find themselves*".

THE RESEARCH METHODOLOGY

This research adopts a different methodology from that prevailing in the NPD literature. As shown in Fig.1, it is not a formal large sample hypothesis testing approach. On the contrary, it stresses an informal subjective and exploratory research approach. Our research logic is to collect effective NPD cases with detailed descriptions of NPD activities available in past studies, extract the central features about the contexts and processes in the case description and try to find out if there is a fit between the contexts and various processes. That is, a trace back logic as shown in Fig. 1. This work is possible because there exists a rich description about NPD processes in recent literature, covering a variety of products and industry types.

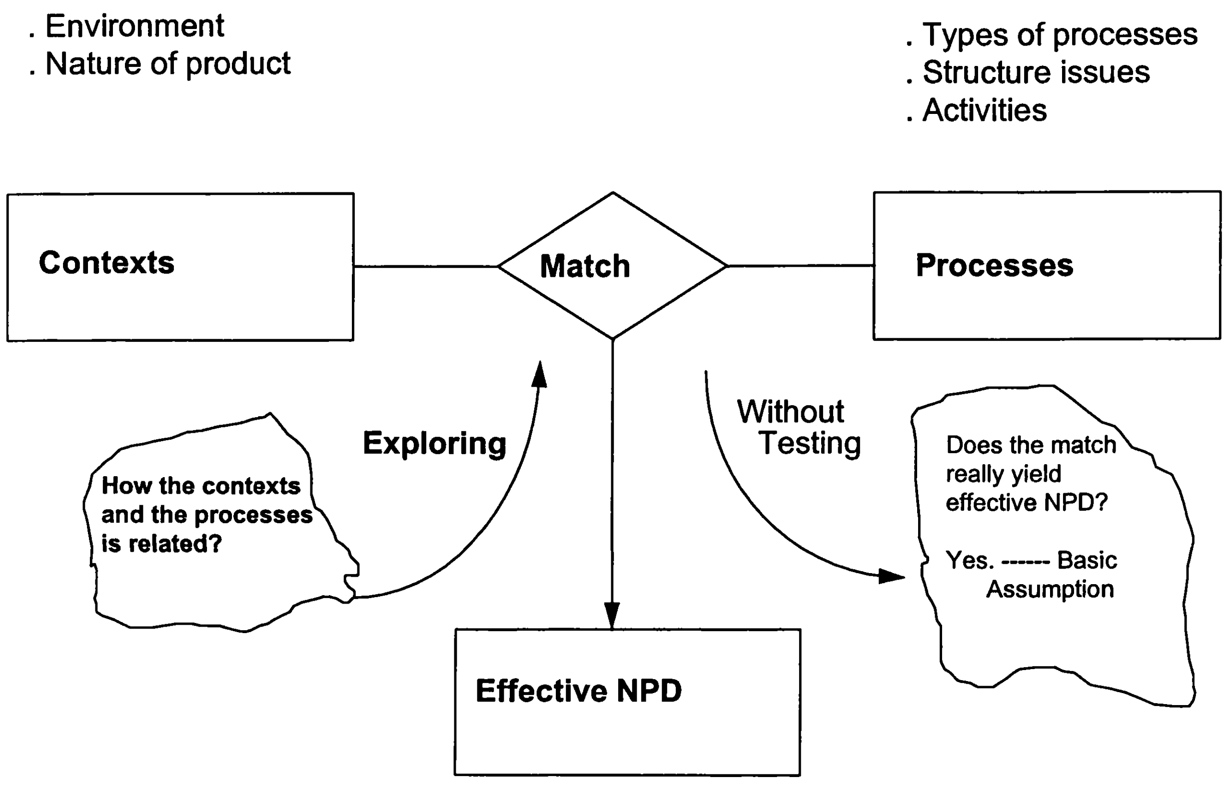

Fig. 1 The basic assumption and research framework

Although the term "new product development process" is widely accepted and used, no formal definition of the term is found. Many authors emphasise the need to better understand the process (Gupta and Wilemon 1986, Purser, Pasmore and Tenkasi 1992). "There is probably a great performance potential to be exploited if only the process could be probably analyzed and understood (Lundqvist 1994)". Cooper (1988) used the metaphor of "game play" to describe the new product development process as a high risk and high outcome process. Takeuchi and Nonaka (1986) compared the new product process to a rugby game to stress team spirit.

Crawford (1994) used the metaphor of carpenter and toolbox to describe the situational nature of NPD. The new product development process described in the context of Crawford, "is a process that covers all types of situations in the most desirable way. Any manager using this generic system must cut and fit it to the situation at hand." On one hand the use of metaphors is heuristic, on the other hand, it shows the complex, flexible and uncertain features of the new product development process. Thus the representation of new product development processes becomes a complicated issue. Although a great deal of effort has been put on the modelling of the NPD, there is no model that is comprehensive and integrated to describe the process (Biemans, 1992).

Our study method starts with repertory grid analysis(RGA), a qualitative technique that uses mathematical presentations of individual's perceptions by linking together relevant constructs to the focus of the analysis. Based on the personal construct theory of Kelly (1955) RGA is a method that is probably best suited to investigating areas that are hard to articulate (Easterby-smith, Thorpe, and Lowe 1991, Fransella and Bannister 1977), especially for complicated processes such as NPD.

Another advantage of repertory grid analysis is that it can provide insight for both the researcher and the researched (Easterby-smith, Thorpe, and Lowe 1991). In our case, the researched are various case descriptions based on narratives of neutral observers such as reporters, experts, and students in NPD. The researcher takes an active, interpretative stance toward the data (Blowers and O'Connor 1995). "In contrast, surveys tend to rely on self-reports of one or two informants in the firm being studied (Golder and Tellis 1993)". At the same time as they try to get rid of their bias, the researchers in survey studies may also lose their valuable insights. In this sense, repertory grid analysis provides a valuable complement.

We follow a modified RGA procedure. There are two changes compared to the general RGA procedure (see Fransella and Bannister (1977) for a detailed illustration, Bradshaw et al (1993) and Latta and Swigger (1992) for recent development):

First, the role of interviewee has been split into two parts: the selective role is taken by the researcher, the narrative role is taken by the case descriptions from the neutral observers. That is, instead of interviewing relevant individuals, cases described in the literature would be consulted. There are two main advantages of using this technique.

- All of the cases are written on paper. Access and replication of the study is relatively easy.
- By laddering and triading different cases, new constructs might appear. Their importance will be judged accordingly and this may enrich current research on NPD processes.

Secondly, because the interviewer's role has been separated, it is possible to duplicate the whole procedure. We enhanced the narrative role of the case description by adding a text description chart to the general RGA procedure. The procedure used in this study will be described in the following section.

DATA COLLECTION

Approximately 200 cases from the literature were collected. 30 cases were selected and analysed finally. The selection criteria of these cases were in line with Golder and Tellis (1993).

- *Competence: Is the case able to report correct information?*
- *Objectivity: Is the informant willing to report correct information (i.e. no vested interests)*
- *Reliability: Is the case a trusted source of accurate information?*
- *Corroboration: Is there confirmatory evidence from a similar source?*

In addition to above case selection criteria, this study required that the description of NPD process in the selected cases have to be comprehensive, e.g. at least including three perspectives of information:

- *Product characteristics: description of the products, especially what makes it new to existing products.*
- *Environment characteristics: description of the industry, the market, and the technology the organisation operates within.*
- *Process description: description of how the product was developed, e.g. people, activities and their relationships.*

For example, cases only describe lessons of NPD success and failure could not be accepted. The sources of the cases were mainly J. Thomas's book *The Successful Story of New Product Development, European Case Clearing House,* and also several other books and periodicals such as *Business Week, The Wall Street Journal, Interfaces.*

The data were analysed by the repertory grid techniques. The analyse procedure was divided into three steps: elicition of constructs; linking each construct to cases to form the grid; and analysing the grid.

CONSTRUCTS BUILDING

In the first step, 30 constructs were elicited from literature and among them 15 constructs were dropped either because no adequate information can be inferred for these constructs from the text descriptions or because it was irrelevant from the context. The final 15 constructs elicited from the literature are listed as follows:

Product Characteristics

1. Newness to market (Booz, Allen and Hamilton 1982, Roberts and Berry 1985)
The extent to which the product is the first of its kind to market.

2. Newness to company (Booz Allen and Hamilton 1982, Robert and Berry 1985)
The extent to which the product is the first to the firm.

3. Newness to technology (Johnson and Jones 1957)
The extent to which the product is a breakthrough to the existing technology.

4. Internal complexity (Clark and Fujimoto 1991)

The extent to which the product has a complicated internal structure.

5. External complexity (Clark and Fujimoto 1991).
The extent to which the product has a sophisticated user interface.

6. Technical uncertainty (Krubasik 1988).
The risk of entering a market with the wrong product

7. Opportunity cost (Krubasik 1988).
The cost of missing a fast moving market window.

Environment Characteristics

8. Environmental hostility (Calantone et al 1994)

Environmental hostility is defined as the extent of threat faced by the firm resulting from the multi-facedness, vigour and intensity of competition. A hostile environment is a frustrating environment that is risky, stressful and dominating. On the opposite side is a benign and encouraging environment, which is safe, rich in profitable opportunities and manipulable or controllable by the organization (Khandwalla, 1977)

9. Environmental uncertainty (Calantone et al 1994)

This is also a very important dimension of the firm's external environment considered by many classical authors like Burns and Stalker (1961), Lawrence and Lorsch (1967). It relates to the level and unpredictability of change in customer tastes, competitive behaviour, technology and source of supply (Miller and Droge, 1986). The increase of uncertainty is said to require less formalised and more flexible structures (Burns and Stalker 1961).

Environmental hostility and uncertainty are two closely related constructs. In fact, Miller and Friensen (1978) termed uncertainty as hostility. The difference between these two constructs lies in that environmental hostility deals with threats to the continued growth of the firm, whereas environmental uncertainty is related to external changes to which the firm must adjust (Calantone, Benedetto, and Bhoovaraghavan, 1994).

10. Firm size (Ettlie and Rubenstein 1987, Damanpour 1992)

Size of the firm may act as an important factor in influencing innovation. The measurement of the firm size is also well documented.

Process description

11. Formalness of the process (Griffin 1993)

The extent to which formal management procedures and activities are carried out in the NPD process(Cooper and Kleinschmidt 1986, Avlonitis 1985).

12. Parallel level (Clark and Fujimoto 1991)

The degree to which NPD activities overlap(Swink, Sandvig, Mabert 1996)

13. Roles by R&D (Cooper 1983, Gupta, Ray and Wilemon 1986)

The degree to which R&D personnel played an important role.

14. Roles by Marketing (Cooper 1983, Gupta, Ray and Wilmon 1986)

The degree to which marketing personnel play an important role.

15. Techniques/models used (Griffin 1993)

Pioneering product development is said to be uncontrollable and unmanageable. There is a question over what role the classic models or approaches in textbooks play during the development of these products. The use of various models and approaches during NPD may vary according to product newness.

Performance metrics were not included because all the cases selected were considered as successful new product development cases. The extent to which the success was achieved and in what prospect the success rely on was not differentiated in this research. Three additional constructs were elicited via triading different cases. They are:

16. Linearity of the process: the extent to which the process can be classified as linear, that is a process with few activities reiterated and almost no feed-back

17. Seniority of the product champion: the extent to which the product champion's power and authority can reach in management and control the resources of the NPD

18. Firm's leading position in the market: the extent to which the firm can be regarded as an incumbent leader in the market.

Like all the constructs in repertory grid technique, these constructs are bipolar. The linearity of the process, for example, refers to the extent to which the process can be classified as linear, that is a process with few activities reiterated and almost no feed-back. The other side of linearity, of course, is a non-linear process characterised by frequent iterations, feedback and design modifications. Firm's leading position in the market refer to the extent to which the firm can be regarded as an incumbent leader in the market. The other end is, naturally, a follower with a humble amount of market share. Seniority of the product champion refers to the extent to which the product champion's power and authority can reach in management and control the resources of the NPD. The two poles of this construct were simply a comparison of senior versus junior. It is worth pointing out that the linearity of the process is independent to the parallel level of the process. That is, parallel activities could be found in a linear NPD process and the parallel level of a non-linear NPD process may be very low.

FORMING THE GRID: LINKING CONSTRUCTS TO CASES

After constructs were determined, each case was searched to find corresponding description for these constructs. Therefore each individual case was linked to every construct via coding the text description of each case. As a result, a case description chart was obtained. The case description chart is a large two dimensional table with constructs as columns, cases as rows. Each cell recorded information from the literature describing the particular constructs in the corresponding case. For example, in the case of Marriott Courtyard (the development of a chain of hotels), the construct description for the construct 'models/techniques used' is: 'Focus groups and hybrid conjoint analysis played a major role. It is an example of using sophisticated models in NPD".

Because the constructs established are all bi-polar, it is possible to transfer the 'soft text' in the case description chart into 'hard numbers'. For example, the constructs 'models/techniques used' has two poles, at one end is ' no models/techniques were used in NPD' at the other end is ' NPD models/techniques were extensively used'. If the case description favour the first end, then a number '1' is assigned. If the case description toward the other end, then a number larger than 1 is assigned. The largest number is 7. In the case of Marriott Courtyard, the rate for the constructs 'Models/techniques used' is 7. Pulling all of these constructs and cases together, a two dimensional 30 by 18 repertory grid was formulated.

It must be stressed that the rate was judged subjectively by the authors according to the case description chart by 7-point semantic differential scales (Fransella and Bannister 1977), which therefore reflects the authors understanding of the cases.

ANALYSING THE DATA: THE PRINCIPLE COMPOTNENT ANALYSIS

The grid was first analysed by principle component analysis using SPSS (Fransella and Bannister 1977) . From the resultant analysis, there were six factors whose eigenvalues are larger than 1. These factors combined together explained 75% of the total variance. Therefore the first six factors with the largest eigenvalues were extracted. Varimax rotation was carried out to find the relationship between the extracted factors and the 18 constructs elicited in the first step. The rotated factor matrix is shown in Fig. 2, where coefficients lower than 0.5 are omitted.

Underlying important dimensions of effective NPD

The most important dimension underlying an effective NPD process was factor 1 which explained nearly 20% of the variance. Factor 1 was strongly related to three process variables: techniques/models used in the process, roles played by marketing in the process, and formalness of the process; two environmental variables: firm's position in the market and firm size.

No.	CONSTRUCTS	F1	F2	F3	F4	F5	F6
15	Techniques/models used	.84					
18	Firm's leading position in the market	.81					
14	Roles by Marketing	.74					
10	Firm size	.71					
11	Formalness of the process	.68					
6	Technical uncertainty		.81				
3	Newness to technology		.80				
1	Newness to market		.64				
7	Opportunity cost			.82			
12	Parallel level			.80			
2	Newness to company			-.58			
16	Linearity of the process			-.50			
4	Internal complexity				.85		
5	External complexity				.84		
8	Environmental hostility					.80	
9	Environmental uncertainty					.73	
13	Roles by R&D					.72	
17	Seniority of the product champion						.84

Fig. 2 Rotated factor matrix

The process variables represent separately a perspective of thoroughness of the NPD process being carried out and the commitment the firm has to carry out such a process. The two environmental variables showed the competitive power the firm might have in the market to develop the new product. Thus this dimension explained **internal/external capabilities** of the firm in developing a new product.

The second equally important dimension was factor 2, which explained 17.2% of the total variance. It was strongly related to three different constructs: technical uncertainty of the product, newness of the product to technology, newness of the product to market. These three constructs were all related to the uncertain nature of the product itself. Hence factor 2 may be identified as **product uncertainty.** It was interesting to notice that the other three seemingly related product characteristics (newness to the company, internal complexity, and external complexity) were not strongly related to the uncertainty of the product. This diversification clearly indicated the role product uncertainty played in effective NPD.

The third important dimension, factor 3, was strongly related to the opportunity cost of the project, and the parallel level of the NPD process. It was also negatively related to newness of the product to company, and linearity of the NPD process. Because all these four constructs directly contributed either as an accelerator or as an obstacle to speed up the NPD process. Factor 3 may be identified as **ability to accelerate NPD process.**

The identification of the fourth dimension was simple. It was strongly related to the internal product complexity and external product complexity. Therefore it was identified as **product complexity.** It was interesting to notice that product complexity played an important but different role from product uncertainty.

The fifth dimension was strongly related to two environmental constructs and one process construct: environmental hostility, environmental uncertainty, and the role R&D played in the process. It showed that in the effective NPD process, the more hostile and uncertain the environment was, the stronger and more effective the role R&D needed to play in the process. The dimension was therefore identified as **pressure for innovation.**

Only one variable was strongly related to factor 6. That was **seniority of the product champion.** This was not a surprise as the role of product champion in successful new product development performance has been identified by many authors (Craig and Hart 1992). However, it was unusual that the seniority of product champion to be identified as an independent dimension in the effective NPD.

DATA ANALYSES: CLUSTERING CASES USING UNDERLYING DIMENSIONS

On the basis of the principle component analysis, a cluster analysis was carried out to distinguish different types of effective new product development. The dendrogram of the clustering result is shown in Fig. 3.

Six different types of effective NPD processes were grouped using within group average linkage cluster analyses. The similarity between different cases is obtained via the calculation of correlation coefficient (COSINE distance) between different cases.

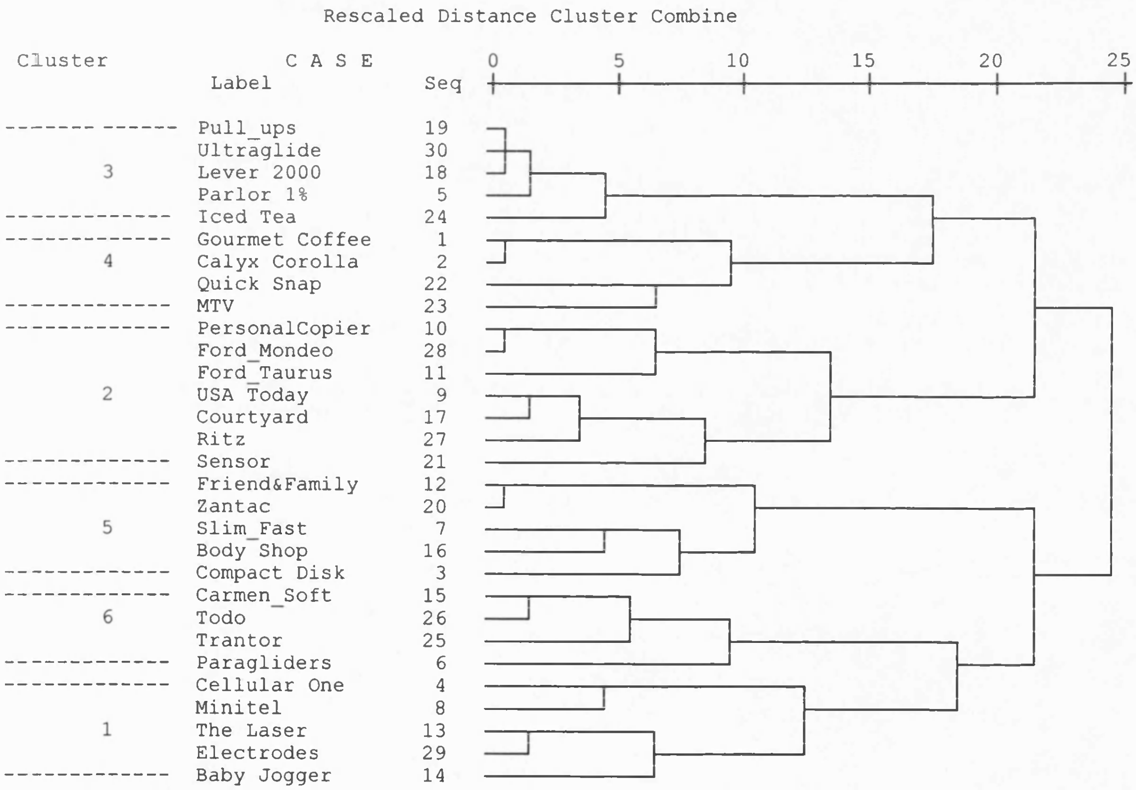

Fig. 3 Dendrogram using Average Linkage (Within Group)

How do effective NPD processes vary along the six dimensions

The differences on the above six dimensions imply clearly different NPD approaches. As shown in Fig. 4, six different approaches(clusters) were identified along with their differences on the six dimensions. The vertical axis shows the mean values of each approach (cluster) on the six factors. These values can only be used to compare different approaches. The approach 2, for example, has a much higher value in factor 1 than the other approaches.

Approach 1: **Radical Product developer** aims at the development of a radical, superior product . The common feature in this group is its high product uncertainty and its low ability to accelerate NPD processes, as is shown in Fig. 4. The product is either new to the market or new to the technology. The company is neither very familiar with the knowledge embodied in the product nor with the product itself. In this case, the process of development can be either formal such as "Minitel" of French Telecom or informal such as "Baby Jogger". There is almost no parallel activities during the process. A step by step approach is chosen. The key in this type of new product development is not to accelerate the process but to find a superior and unique product that can meet the new demand of the market.

In order to find such a superior and unique product a certain amount of learning and experiments is needed that requires a suitable environment so that in one hand innovation is encouraged and on the other side trials and errors are allowed.

Proposition 1. The serial radical product developer will yield positive performance if the product is developed in a context with moderate pressure for innovation to cope with the environment.

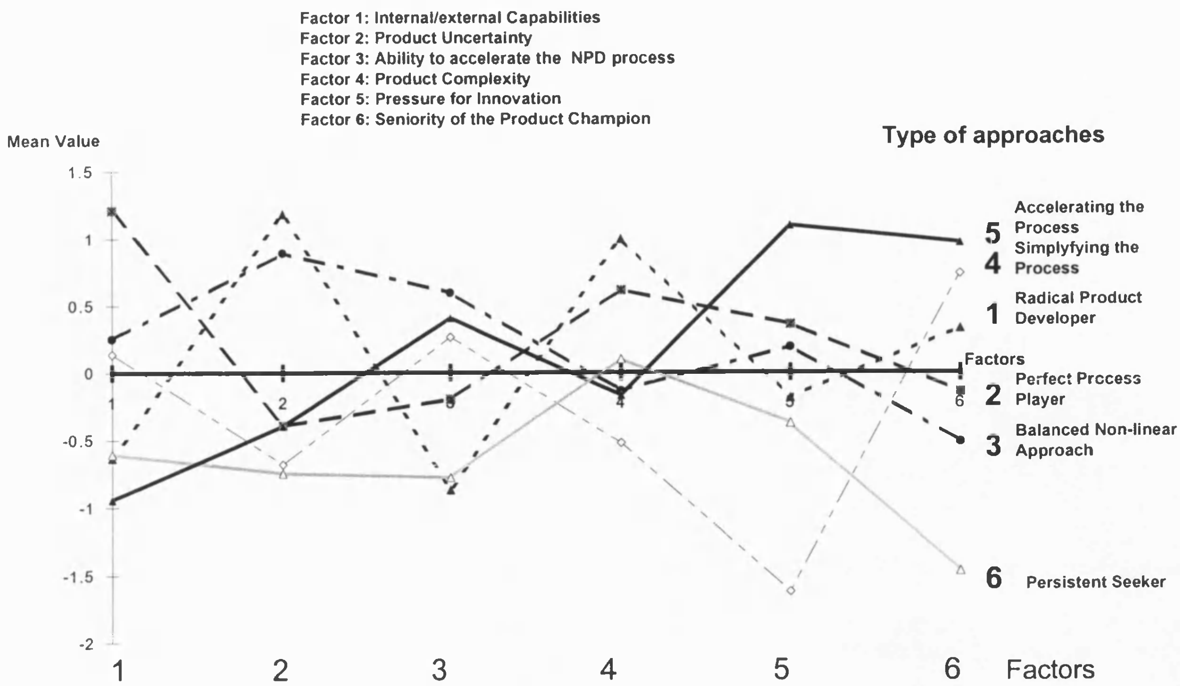

Fig. 4 How do effective processes vary along the six dimensions

Approach 2: **Perfect process player** seeks significant modifications of existing products via a 'perfect' process. Among this cluster are firms that are strong leaders in the market. The purpose in developing a new product is to strengthen the leading position of the firm in the market. The distinguishing feature is that they all share higher value in the first dimension, that is, high capability to develop a new product in the market (see Fig. 4). The NPD processes are carefully designed and carried out and applications of the techniques/methods from innovation management research in these processes are very common such as the application of simultaneous engineering in the development of Taurus, conjoint analysis in the design of Coutyard by Marriott. The product development processes in this cluster are complete and thorough. The parallel level of activities in the NPD process, however, varies from product to product. The development of Ford_Taurus, for example, is highly parallel. While the development of Gillette Sensor shaving system took place over 13 years. It follows a non-linear but step by step approach. In this group, speed may or may not be a demanding requirement. However, this approach is by no means universal and it may not be proper to be used to the type of new products other than "the big jumps".

Proposition 2. Perfect process player will yield positive performance if the product is moderately innovative.

Approach 3: **Balanced non-linear approach**. There are two distinguished features in this approach. First, it is balanced, both R&D and Marketing played an important role. Secondly, the NPD process in this group is not as thorough as in the perfect process player approach. But key activities in the process would not be omitted (such as the development of Ultraglide of Calor). In a word, it follows a step by step approach with possible over-lapping between activities and the development process is not linear. The result showed that:

Proposition 3. Balanced non-linear approach will yield positive performance if the product is a major innovation with moderate complexity.

Approach 4: **Simplifying NPD processes** by omitting unnecessary activities. Many activities that are considered necessary in the innovation literature are omitted in this cluster. An informal process often accompanied by entrepreneurial insight were used instead such as the development of Gourmet Coffe (a new way of drinking coffe) and Calyx Corolla (a new flower delivery service), a flower delivery service. Two common features of this cluster, as shown in Fig. 4, are low product development uncertainty and low pressure for innovation to cope with the environment. In our research, all of the 5 cases that adopt this approach are aimed to develop incremental products. It has similar features with the persistent seeker approach, but this approach is more active.

Proposition 4. Simplifying the process approach would yield positive performance if the product has a relatively low development uncertainty and high seniority of the product champion.

Approach 5: **Accelerating the process:** developing a new product in a highly competitive and hostile environment. In this group, the development cycle is cut short via maximum parallel level of the process (such as MCI's development of Friend & Family service) or seeking strategic alliances to overcome the possible obstacle (such as Phillip's development of Compact Disk). This cluster is identified with high value on both the fifth dimension, that is, pressure for innovation to cope with the environment; and the sixth dimension, that is, the seniority of the product champion.

It is often than not, this approach is taken when time is an important factor in gaining competitive advantage. It is interesting to note that such an approach is usually developed in a highly competitive and hostile environment.

> *Proposition 5.* Accelerating the process approach will yield positive performance if the product has a relatively low uncertainty, high seniority of the product champion, and high pressure for innovation to cope with the environment.

Approach 6: **Persistent seeker** of new product. The processes in this cluster are by no means perfect. Most of them are restricted by various factors, lack of financial support in the development of Trantor, for example. But continuous effort of developing the product paid off finally. The common features in this cluster are low ability to accelerate the NPD process and relatively low product uncertainty. It is often called the "lucky innovator".

> *Proposition 6.* Persistent seeker approach will yield positive performance if the product is developed with low product uncertainty in a currently ignored potential market.

Managerial implications

In this exploratory research, six types of effective NPD are identified. In the past literature, many authors stress the need for a generic best practice in NPD. Various ways or factors about the "silver bullet" which help to distinguish the "winner" from the "loser" were suggested. Proficiency and quality of the process and up-front "homework" such as pre-development study were stressed. However, the results of this research show that there is no generic "best practice" in NPD. Although seeking a perfect NPD process is very important in some circumstances (such as the type 2 performer in our classification), effective NPD can be achieved via non-perfect NPD processes. The tedious "homework" can be omitted or replaced by entrepreneurial insight in a certain number of circumstances. This research helps to identify these circumstances and it would be useful for managers in designing their NPD processes according to the context they operate within. It showed that following managerial aspects should be stressed in effective NPD:

- *The effective development of a new product differs from product to product; in designing their new product development processes managers must have a clear view of the context in which their new product is to be developed.*

- *In aiming at the development of a radical new product, the emphasis should not be on the completeness and thoroughness of the process, neither should it be put on accelerating the process via increasing the extent to which NPD activities overlap. The key is to find a superior and unique product that can meet the new demands of the market.*

- *Simplifying NPD processes without damaging the effective NPD may be achieved in a circumstance where both product development uncertainty and the demand for innovative strength of the firm to cope with the external environment are small.*

- *Seniority of the product champion should be stressed when the product is developed in a highly competitive and hostile environment and required to short the product development cycle. Ability to accelerate the process in this case is a pre-condition.*

- *Significant modifications of existing products, developed in a firm with higher internal effort/external capability of NPD, require higher quality NPD processes.*

CONCLUSIONS

Through a modified repertory grid analysis, we found three important constructs for effective NPD that are not covered in the literature. Through factor analysis, six dimensions were identified, which were critical in describing the differences of underlying NPD processes. This partly confirms and also extends Krubasik's NPD map (1988) where only development risk and opportunity cost were considered. Differences on the six dimensions were found to form different NPD approaches. This may imply useful information for managerial reactions. Although efforts have been made to make this study replicable, it must be remembered that this research is based on the 30 cases available in the literature and it is a non-probability sample and being subjectively analysed by the authors using qualitative exploratory procedures. Although there is no intention to cover all possible approaches of effective NPD, re-organising and re-analysing these best practices in the literature is certainly helpful to discover a variety of important approaches in different NPD contexts. Therefore it is useful for managers to identify those similar situations they get involved in and adopt corresponding managerial reactions.

REFERENCES (SEE BIBLIOGRAPHY)

Appendix III An Example of the Cover Letter and the Postal Questionnaire

Mr. David Thompson,
Managing Director,
ARC Computers Ltd.,
12 Facey Way,
Swindon.
SW2 7AY

Dear Mr. Thompson,

<u>Searching for the 'ideal' way to develop new products!</u>

Many managers and writers believe that there is an 'ideal' way to develop new products that will guarantee success when they are launched. I am a PhD student, researching effective new product development for electronic and telecommunications products, and I am veryskeptical of such a view! I am seeking your valuable expertise to help me uncover different types of development process that match different product types.

I have enclosed a short questionnaire that should take no more than 10 minutes to complete. It is designed to understand your organisation's involvement in the New Product Development Process and your reflections on the experience of a successful development process.

In order to successfully complete this questionnaire, you should have a general familiarity with New Product Development processes in your organisation. The questionnaire focuses upon a product that you will nominate. It does not necessarily need you to divulge any current developments of potentially sensitive information. The information supplied by yourself will be handled in the strictest confidence, and will not seen by anyone else except in an aggregated form, for bona fide research purposes.

Every survey emphasises their importance, this questionnaire is no exception. I feel that if I can highlight the differences involved in developing new products, valuable lessons will be made for British Industry. If you would like a copy of my final research findings, please tick the box on the questionnaire.

Thank you very much in anticipation of your help.

Yours sincerely,

Zhongqi Jin

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SURVEY INTO THE IMPACT OF PRODUCT NEWNESS ON NEW PRODUCT DEVELOPMENT PROCESSES

SECTION 1: GENERAL DESCRIPTION OF YOUR ORGANIZATION'S INVOLVEMENT IN NPD

1. What type of organization do you work in?

☐ Wholly UK owned ☐ International with UK headquarters ☐ UK subsidiary of a multi-national (1)

☐ other (Please specify) ______________________________

2. Has at least one new product in your UK operations been made available for sale in the last 5 years?
(For the purpose of this survey, new product means new to your firm even though similar products may already have been on the market.)

☐ Yes (Please go to Question 3) ☐ No (Please go to page 4 and answer Questions 17 to 20) (2)

3. Please tick one of the following that best describes your UK OPERATIONS' involvement with the New Product Development (NPD) process

☐ We get involved in the whole procedure of NPD (from idea generation until launch, etc.) (3)

☐ We only participate in part of the NPD.

☐ We do not develop new products, we are only responsible for the manufacturing of products.

☐ We do not develop new products, we are only responsible for the distribution of products

SECTION 2: YOUR INVOLVEMENT WITH A PARTICULAR NEW PRODUCT: NEWNESS AND PERFORMANCE

4. The following set of questions will relate to your recent experience of developing a new product. In order to make this research meaningful, it would be helpful if you could "nominate" a product that you personally worked on.

Product name: ______________________________ (4)

____

Could you briefly describe the product and what you see as its key characteristics, in particular, what made it new at the time it was made available for sale to your customers?

______________________________ (5)

____

____

What was your role in the development of this product? (8)

____

5. *How long ago was this new product made available for sale to your customers?* (9)

☐ 1 year ☐ 2 years ☐ 3 years ☐ 4 years ☐ 5 years

Other (please specify)______________________

6. *Which category do you think this new product belonged to?* *(Tick more than one if applicable)*

☐ **Improved product**: a development of an existing product (10)

☐ **Product line extension**: a product that is new to the organization but "fits" with the existing product lines. (11)

☐ **New product line**: a product new to the organization which allows the organization to enter markets in which it has no previous experience. (12)

☐ **New to the world product**: a product new to both the organization and the world. (13)

☐ Other (please specify)____ (14)

7. *To what extent do you agree with each of the following statements about the newness of this product?*

(Tick as appropriate)

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	
The new product was mainly purchased by our existing customers						(15)
There were no new competitors at all for this product at its launch						(16)
It was targeted to satisfy a new market for us						(17)
We organised a new sale force particularly for this product						(18)
Completely different media types of advertising/promotion programme were used for this product						(19)
New methods were used for market research in its development						(20)
This product belongs to an existing product category of our organisation						(21)
The technology was already embodied in our organisation before the product development began						(22)
This product needed little modification of existing engineering/design work						(23)
There was almost no modification of existing manufacturing processes						(24)
The key ideas that make this product have significantly advanced existing knowledge of the current technology capability						(25)
The linkage between the key ideas of the product have significantly advanced existing knowledge of the current technology capability						(26)

8. *To what extent do you agree with following statements about the product's performance?* *(Tick as appropriate)*

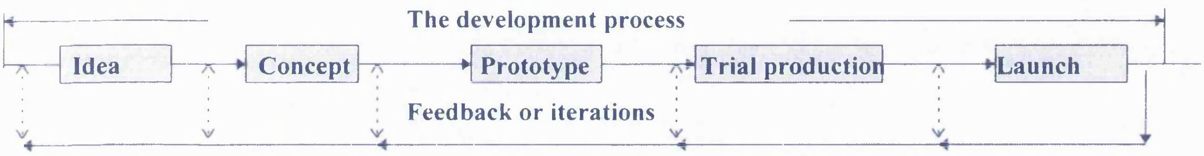
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	
The product has met market share goals						(27)
The product was enthusiastically welcomed by consumers						(28)
The product has provided a measured increase in customer satisfaction						(29)
The product has met the profit goals						(30)
The product has met margin goals						(31)
The product has provided a distinct competitive advantage						(32)
The current estimate of Return-On-Investment(ROI) on the project has met original criteria						(33)

SECTION 3: THE DEVELOPMENT PROCESS: FROM THE FIRST IDEA GENERATED UNTIL LAUNCH

9. To what extent do you agree with following statements in describing the development of this product?

	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree	
The development process was totally unstructured: everybody involved in the NPD process was allowed to be creative and to do almost as (s)he pleased.						(34)
There were precise dates for the start and the completion of the activities to be undertaken during the development process						(35)
During the development process, project progress was formally monitored						(36)
The development process proceeded by means of a well-documented plan of action						(37)
Marketing personnel played a very limited role in the development process						(38)
The marketing project members had a strong technical orientation						(39)
Some of the marketing project members also performed technical tasks						(40)
R&D personnel played a very limited role in the development of the product						(41)
The R&D project members had strong business orientation						(42)
Some of the R&D project members also performed marketing tasks during the development of this project						(43)

The following section has a series of 7 point scales with diametrically opposed views on the sequence of events in the NPD process. These events are represented in a simplified model shown as follows



Where **Idea** *refers to a stage or activities to generate and screen product ideas,* **Concept** *refers to a stage or activities in which a refined product idea was generated and tested to determine consumer acceptance,* **Prototype** *refers to a stage or activities in which prototypes of the product were designed and tested,* **Trial production** *refers to a stage or activities in which a small amount of products were produced. A product development may experience all or part of these stages. The following questions concern the sequence of these activities and the iteration that occurred during the product development process.*

10. Did the development process have a distinct (Tick as appropriate)

Idea Stage? ☐ **Concept stage?** ☐ **Prototype stage?** ☐

Trial Production stage ? ☐ (44-47)

11. With regard to the new product you nominated in Q4, please indicate the extent of overlap of the various stages or activities (Circle the most suitable number that shows which extreme you tend towards).

The idea stage and the concept stage were carried out in sequence, there was almost no overlapping	1	2	3	4	5	6	7	The two stages were conducted almost at the same time	(48)
The concept stage and the prototype stage were carried out in sequence, there was almost no overlapping	1	2	3	4	5	6	7	The two stages were conducted almost at the same time	(49)
The prototype stage and the trial production stage were carried out in sequence, there was almost no overlapping	1	2	3	4	5	6	7	The two stages were conducted almost at the same time	(50)
The idea stage and the prototype stage were carried out in sequence, there was almost no overlapping	1	2	3	4	5	6	7	The two stages were conducted almost at the same time	(51)
The concept stage and the trial production stage were carried out in sequence, there was almost no overlapping	1	2	3	4	5	6	7	The two stages were conducted almost at the same time	(52)

Appendix IV An Example of the Questionnaire for The Telephone Survey Work

Contact section:

Record No:1 Name of the company:I B M UNITED KINGDOM HOLDINGS LIMITED

Tele:01705 564000

Q1 New product development is part of the company's business Yes ☐ No ☐

Q2 The person who has a general familiarity with new product development

Name: ______________________________ ***Title***: Mr/Mrs/Ms

Position: ______________________________

Original Telephone:01705 564000

Telephone (If different from above):______________________________Ext:__________

Name of company:I B M UNITED KINGDOM HOLDINGS LIMITED

Original address:P.O. BOX 41, NORTH HARBOUR, PORTSMOUTH HANTS PO6 3AU

Address: ______________________________ *(Road)*

(If different) ______________________________ *(Town)*

______________________________ *(County)*

______________________________ *(Postcode)*

Summary section

1. To what extent do you think the respondent would complete and return the questionnaire?

Definitely not ☐ Less likely to response ☐ Possible ☐ Highly possible ☐ Definitely will ☐

2. Number of calls you had for this company: 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

3. Brief comment and suggestions for further contact:

____

____

Appendix V Guideline for the Telephone Survey Work

Purpose

. Find out the person who has a general familiarity of NPD activities in the firm

. Persuade them to participate the survey

Steps

Step 1. Phone the company and ask them to put you through strategic manager, NPD manager or Marketing manager of the company.

For large firms, the business strategy director might be the most suitable person to talk to. It is always recommended to talk to marketing manager not the operator of the switch board in detail. Try to get through the operator as fast as you can to avoid to explain yourself and your purpose of phoning the second time.

For medium firms, you may find new product development manager or technical director helpful.

For small firms, it is better to describe your purpose of the call first. Tell them you are doing a research into new product development and ask them to put you through to the person who has a general familiarity with new product development. It is more often than not, you will be put through the managing director of the firm. So you should be prepared to have a thorough reading of the background materials in advance.

(e.g. I am...., could you put me through to the marketing manager please?)

Step 2. Introduce yourself briefly and the purpose of this phone call. (An introduction material is attached to explain briefly the purpose of this study. Please read them carefully, you may need them to explain in detail about this research)

(e.g. I am Arthur King, I am doing a research about new product development, ..., I am concerned with how different types of new products were developed successfully, given some products were new to the company, some were mere modifications of existing products, I'd like to explore the impact of newness on the new product development process, its relationship with product performance, ..., etc.)

Step 3. Asking questions and trying you best to dig out a person in the company who is suitable to contact.

(e.g. Could you suggest me someone in your firm who has a general familiarity about new product development, ..., I'd like to send you the questionnaire I have designed for this purpose at the middle of January, ...)

Step 4. Taking the person's name, checking the postal address, checking the company name, and Concluding the phone call politely.

Step 5. Completing the summary section of the telephone list.

Important Note:

Please keep in mind, it is important to

1) Check the company name (The name of the company you phoned may be different).

2) Check the company address (The address of the company may change)

3) Ask for the person's position in the company

4) Print the information clearly

Introduction of the research

RESEARCH TOPIC: EXPLORING EFFECTIVE NEW PRODUCT DEVELOPMENT PROCESS FOR INFORMATION AND COMMUNICATIONS TECHNOLOGY PRODUCTS

Recent ten years has seen rapid progress in new product development(NPD). Many formal or informal NPD processes such as stage-gate process, QFD, concurrent engineering, cross-functional teams, etc. have been adopted and used. But to what extent these methods are effective, how to customize them into a particular context which is suitable to a specific company?

This research project intends to investigate how different types of new information and communications technology (ICT) products should be developed giving that some of the products in the market are really new and radical to the company, while some are merely the modification of existing products. The argument is, to gain a better performance, different products in different contexts may need different development approaches.

Despite its academic orientation, this is a practical study because the results can give managers a clear guide on how to build up awareness of product newness in developing a new product. It will identify clearly what is most likely to go wrong if the project manager uses improper approaches to develop a new product in a particular context. Therefore the research will help product developers to avoid potential trap before and during development processes and it will improve product performance and reduce the possibility of failure.

We expect to talk with managers who have experience in new product development preferably in developing different types of products. It will cost each manager one and a half working hours for three interviews designed. As indicated above, the research results will certainly beneficial to the participating company to gain competitive advantage in this innovative market. A final report of the research result with emphasis on the comparison of your company's new product development performance with the general stream will send to you upon request. We stress that the information obtained via interviews or other means will be kept in the strictest confidence.

Appendix VI Increasing the Response Rate in Constricted Industrial Mail Survey: Some Considerations

INTRODUCTION

In his well-known methodology textbook, Kenneth D. Bailey (1987) summarised eight main advantages for mailed questionnaire such as saving of money, saving of time, standardisation, and no interviewer bias, etc. Because of these advantages, mail surveys have been used and are continuing to be used in many areas. The wide-spread usage of mail survey, however, brought unexpected side effect on the further use of the tool. Non-response, for example, has become one of the major problems a mail survey researcher has to cope with. It is estimated that the average response rate of mail surveys fell down at least 10% in last 20 years. Thus it is not a surprise that there exists a huge literature in searching of various ways to increase the response rate (Miller 1991). Various factors that may influence the response rate were examined, and a lot of methods to administer the postal survey were proposed. Taking all of these factors considered and carrying out methods recommended in the literature, postal surveys will not have the advantage of time saving and money saving. Telephone pre-notification, for example, will greatly increase the cost. Personalization, on the other side, will need more time and efforts to be put in. In addition, among the huge amount of research into increasing response rate of mail survey, few of them deal with industrial population (Jobber 1986). Most of them set focus on non-industrial investigation that has fundamental difference with the former. So a problem remains unsolved in the literature that how the response rate of a constricted industrial survey can be increased. In this essay, the main characteristics of a constricted industrial mail survey (CIMS) will be discussed. A framework to increase the response rate of CIMS will be proposed, which is critical to students who collect data via CIMS. Further discussion and conclusions will be presented at the final part of the essay.

WHAT IS A CONSTRICTED INDUSTRIAL MAIL SURVEY

By constricted industrial mail survey we mean that the survey is mainly administered in a postal form to the industrial population with limitation on survey resources, involving limitation on time and efforts to be put in, limitation on budget, limitation on size of survey research teams, etc. According to the definition, CIMS is characterised by following two main factors:

<u>1. Limited resources</u>

One of the most distinguishing features of the CIMS is its limited resources. This is a problem often encountered by an independent researcher who chooses mail survey as a major means of data collection. It is more often than not, his or her budget is quite limited and he or she has to do all the work by (him/her) self. There is no doubt that many other researchers either independent or being sponsored also suffered from limited funding sometimes. Therefore some activities aimed at increasing the response rate are unable to be carried out. Monetary incentives or non-monetary incentives, for example, are proved both playing a positive role in improving response rate. It is unlikely to be used by a researcher with limited budget in this case. An independent researcher has also limited time and energy to manage the mail survey. Personalization of the survey letter is regarded as a positive factor to increase response rate by some authors. A postgraduate student by research, however, may lack the time and energy to personalise all respondents because that may demand months of work. To make things worse, CIMSs are usually not sponsored by a well-known entity that is also a potential factor that can influence the response rate. So limited resources are by no means a positive factor in increasing the response rate. In fact, the low response rate not only reduced the representative level of the sample but also increased the cost. It is a double edged sword that needs to be well managed.

2. Different Populations

Because of limited resources, researchers who carry out the CIMS must dig out every aspect of the trick. Population to be surveyed is of course a very important factor. According to Dillman (1987), the key in managing mail survey is mastering the role of social exchange. Therefore it is important to understand the population first before considering how to stimulate the input to maximise the gain.

Industrial population differ from non-industrial population in following aspects:

First, the respondents in industry differ from non-industrial respondents in terms of status and their professional habits that might have some influence on the ways the respondent reacts to the questionnaire and therefore the management of questionnaires must reflect this change. It is a well-known fact or an established way of doing things in mail surveys, for example, that a stamped or pre-paid return envelope is always included along with the questionnaire and the cover letter sent. For a sample of presidents of large corporations, Kerin and Harvey (1976) made an interesting experiment in which two manipulate variables were included: stamped return envelops and no stamp on return envelops. The response rate on the former was 34%, while it turned to be 37% on the latter.

Secondly, as suggested by Jobber (1986), industrial respondents likely differ from non-industrial respondents in where and when the questionnaire is completed. In fact most of the industrial questionnaires are likely completed at work during company time, instead of completed at home during leisure time (Jobber, 1986). So to get the permission of the boss of the respondent might be an effective way in increasing the response rate. Some authors (such as Kwandwallar in 1976) use the strategy wisely. To arrange the questionnaire reaching the respondent in a work day is also worth considering because improper timing may alienate a potential industrial respondent.

Thirdly the natures of the inquire may differ. An industrial inquiry may pay less concern on individual's personal sensitive issues but most likely on information about his/her company. The questionnaire usually asks the respondents to reveal information that may not be their own property, but that of their company's. In this case, how to stress the confidentiality and the anonymity to release the worry of the potential respondents may differ from what should have done in existing literature that mostly aimed at non-industrial population or paid less attention on the population difference.

In summary, although CIMSs share many common points with non-CIMSs, the above two factors need special consideration in order to improve response rate.

HOW TO INCREASE THE RESPONSE RATE OF CIMS

Given the difficulty encountered by CIMS, it is important to pay much attention to increase the response rate. Unfortunately, as suggested by Jobber(1986) in his extensive review, "Most of previous studies reviewed cover non-industrial populations, ..., little or no attempt is made to identify differences between population types." Although the problem of industrial survey has been recognised by more and more authors in recent years (Haggett and Michell 1994, Chawla and Nataraajan 1994, Kalafatis and Tsogas 1994), only some individual factors that may influence industrial surveys were examined. There is no attempt in the literature to deal with the non-response problem for CIMS. One of the few relevant articles is from Walker, Kirchmann and Conant (1987). Having overviewed the applications of Dillman's Total Design Methods on industrial marketing studies, they applied cost-benefit analysis on factors that may influence the response rate of CIMS. Although there is inconsistency or even contrary between the result they obtained from cost-benefit analysis and the result revealed by later studies, although their results obtained is far from quantitative that may be a big obstacle to apply the methods for CIMS, their work provides an insight into further analysis on cost estimation of the various factors accounted in the literature. But they failed to indicate that on the condition of limited resources how the maximum benefit can be obtained. Jobber (1986) made an extensive review of experimental research on improving response rates in industrial mail surveys. Three important aspects of available techniques were identified: preliminary notification techniques, concurrent techniques, follow-up techniques. But no attempt is done to integrate these effective techniques that may be more useful for practical researchers for the sake of increasing the response rate. A better position therefore lies in the effort to combine these two stances of work in the literature and to apply it for CIMS. We argue that because of limited resources of CIMS, individual techniques developed in past studies cannot increase the response rate of CIMS significantly. Some of the techniques may not be feasible due to limitation on available resources. It might be, however, possible to increase the response rate of CIMS via a comprehensive consideration of all factors that may influence the CIMS.

On the basis of these considerations, we propose a four step procedure to attack the problem:

First, listing all the factors that may influence the response rate. Existing literature revealed a huge amount of factors that may influence the response rate. As these efforts were usually individually stated, we combine them in an integrative conceptual framework as shown in Fig. 1. The conceptual framework consists of four parts: prior commitment setting; better design efforts; choosing optimal mail strategy; and making maximum use of follow-up effort. Detailed description of the framework, however, is well beyond the scope of this essay.

Secondly, analysing the characteristics of the potential survey. Much attention should be paid to the characteristics of population and the nature of the inquiry, as we have suggested that the difference of these characteristics might influence significantly on the cost of the survey

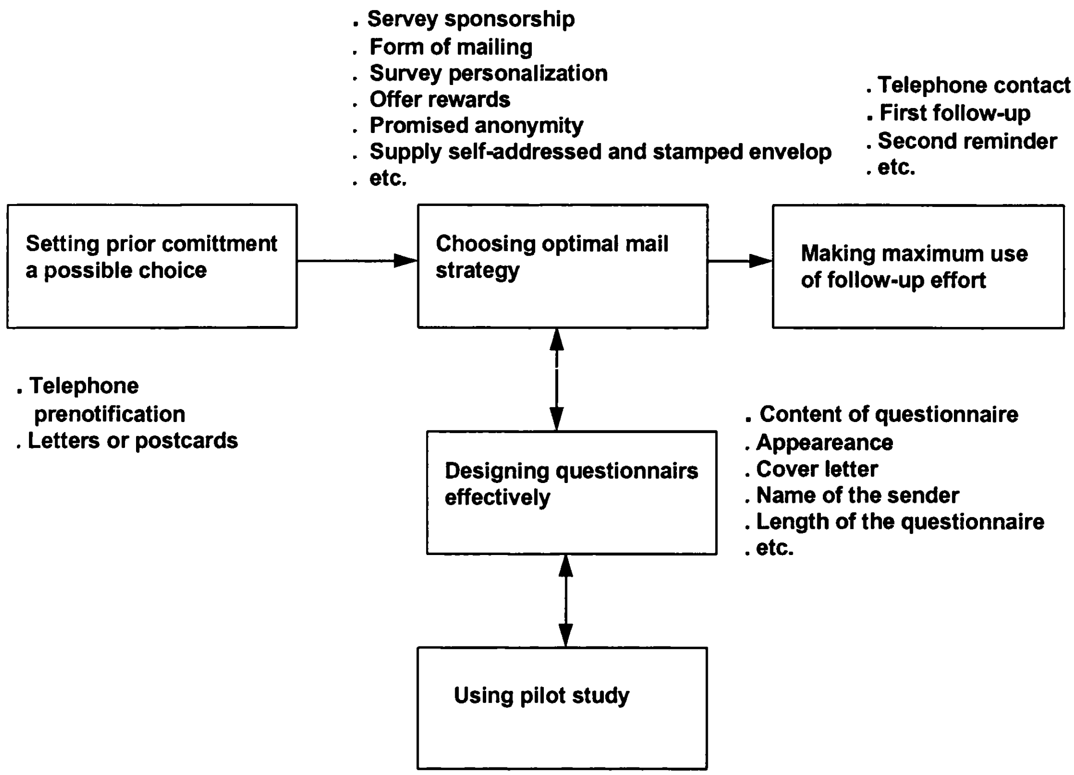


Fig.1 Increasing the response rate of CIMS: a framework of potential techniques

and the response rate. For example, the researcher's names (Christian names or foreign names)are identified important for different respondent population (Chawla *et al* 1994). An increase in response might be possible on the cost of changing the name of the researcher.

Thirdly, estimating the cost and benefit of all these factors for the specific survey to be carried out. Unfeasible factors may be identified and eliminated. On the basis of the estimation of the cost and benefit, a better decision may be possible to be made on a comprehensive CIMS strategy.

Fourthly, choosing flexible strategy for the administration of the questionnaire. For example, if the statistic requirement of sample size is 300, estimated response rate is 30%, then 1000 questionnaires need to be sent. We argue that instead of sending 1000 questionnaires in once, sending part of them first, say 600 for example, because it is relatively hard to estimate the response rate accurately in advance. If the response rate turned out to be 50% or more, the statistical requirement is met. There is no need to sent the other 400 questionnaire out. The cost is reduced. If the response rate is lower than 30%, however, serious consideration must be made on the over-all strategy of the survey design. This is different from pilot study because the former's sample size are usually very small and it is therefore difficult to predict the response rate in advance. By identifying the lower response rate problem of the first 600 questionnaires, a remedy may be called on to deal with the rest 400. Over-all cost per questionnaire might be reduced in this way. The strategy is illustrated in Fig.2.

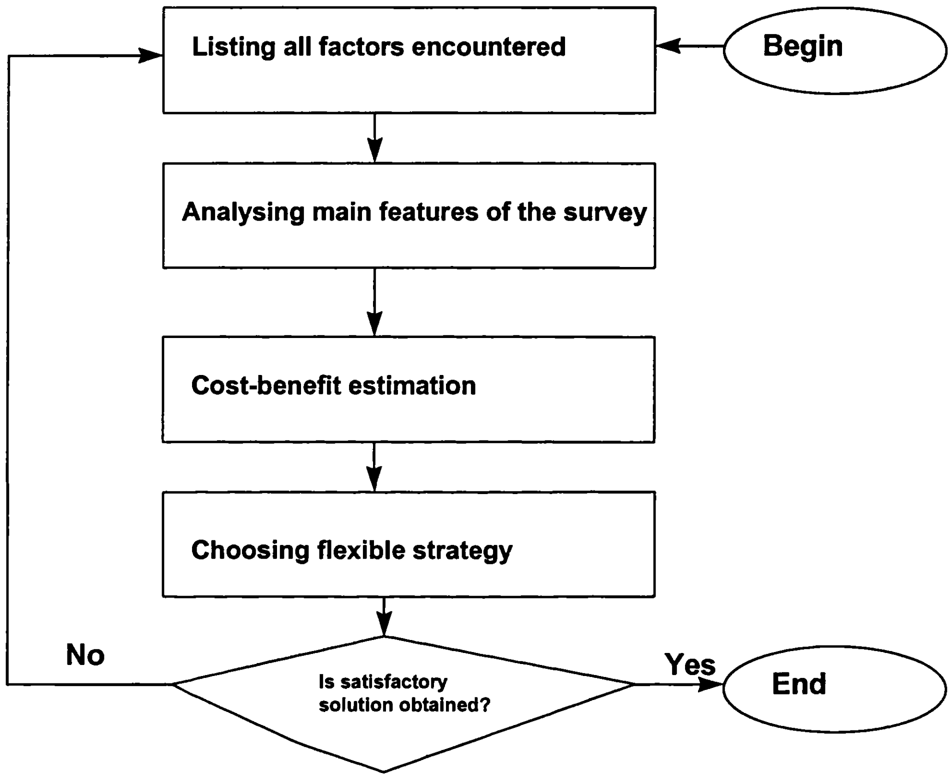


Fig. 2 Increasing the response rate of CIMS: a flexible strategy

FURTHER CONSIDERATIONS AND CONCLUSIONS

In this essay, we have described what is a constricted industrial survey and difficulties researchers may face when CIMSs are carried out. Suggestions about how to increase the response rate of CIMS are then discussed. It is believed that the strategy proposed not only is beneficial to CIMS researchers but also provides a valuable hint to other kinds of mail surveys under the limitation of resources. Finally, it is worthwhile to pointed out that the problem of increasing the response rate of CIMS or finding a right way to get enough number of returned questionnaires in a survey can be regarded as a restrained optimisation problem. The quantification of cost and benefit of the influence variables remains a good direction for future research.

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Appendix VII An Example of the Telephone Support Questionnaire

Ref No: 7.0 Mail No.: 132.0

Mr. Ian Mackinnon Product Manager

DIGITAL EQUIPMENT SCOTLAND LIMITED

MOSSHILL INDUSTRIAL ESTATE
AYR
KA6 6BE

Telephone:**01292 266955**

1. Status of response *(Tick as appropriate)*

☐ Not aware of the coming of the questionnaire

☐ will return the questionnaire shortly

☐ will not return the questionnaire

☐ already returned the questionnaire (approximate date of return(dd/mm/): / /)

☐ others(specify)______________________________

____

2. Reasons of non-response *(Tick as appropriate)*

☐ The person was not available.

☐ The company did not develop new products

☐ The questionnaire was misplaced

☐ It's against the company's policy to reply

☐ The company does not belong to the ICT industry

Others (specify)______________________________

____

3. Action needed *(Tick as appropriate)*

☐ Sending another questionnaire

☐ Waiting for response

☐ Drop the case

Note: ____

Appendix VIII The Linearity and Product Newness: the Data Analysis

The objective of this appendix is to provide a more detailed account for the results presented in Chapter 6, section 6.2.2 and section 6.2.3. It is divided into two parts. Part A, the explorations, corresponds to section 6.2.2 and Part B, the interaction effect, corresponds to section 6.2.3.

A. The linearity of NPD processes and product newness: the explorations

An exploratory analysis was done which used three equations: 1) Joint influence without interaction: putting all product newness variables and their higher order items together but without adding interaction of these variables 2) Joint influence by adding interaction items 3) Considering the effect of other variables. The data analysis procedures and the final results will be exhibited as follows:

1) Joint influence without interaction

The influence of the three perspectives of product newness to the linearity of NPD processes can be described in the following equation:

$$\text{Linearity}=b0+b1*\text{cnewer}+b2*\text{cnewer}^2+b3*\text{cnewer}^3+b4*\text{tnewer}+b5*\text{tnewer}^2+b6*\text{tnewer}^3 +b7*\text{mnewiner}+b8*\text{mnewiner}^2+b9*\text{mnewiner}^3 \qquad (1)$$

```
Where cnewer=cnew-mean of cnew: centered value of product newness to
      market
      tnewer=tnew-mean of tnew: centered value of product newness to
      technology
      mnewin=1/mnew, the inverse of product newness to market
      mnewiner=mnewin-mean of mnewin: centered value of mnewin
```

This equation considered all the three perspectives of product newness as well as their higher order items. To overcome potential collinearity problems the higher order items may bring about, centered values of these variables were used. The methodological advantages of the centering technique can be found in Aiken and West (1991). The inverse value of mnew was used because the existence of the negative relationship between product newness to the market and the linearity of NPD processes and this transformation was also helpful in reducing the multi-collinearity between different product newness variables. The estimation results for equation (1) are shown in Table 1.

Table 1 Linearity and newness: further explorations

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	4.089	.150		27.276	.000		
CNEWER	.114	.188	.092	.609	.543	.245	4.083
CNEWER**2	.109	.098	.104	1.111	.268	.634	1.578
CNEWER**3	-4.0E-02	.072	-.092	-.563	.574	.208	4.811
TNEWER	1.5E-02	.192	.012	.077	.939	.240	4.166
TNEWER**2	7.6E-02	.087	.081	.882	.379	.664	1.507
TNEWER**3	-1.1E-02	.066	-.029	-.175	.862	.204	4.894
MNEWINER	2.487	.940	.421	2.645	.009	.220	4.547
MNEWIER**2	4.649	3.700	.258	1.257	.211	.132	7.582
MNEWIER**3	-15.578	9.232	-.458	-1.687	.093	.076	13.230

R^2=0.11 F(9,160)=2.141 Sig. F=0.029

Table 1 shows that the joint influence of product newness variables can explain 11% of the total variance of linearity of NPD processes. The influence of product newness to market (mnewiner) is still significant (p=0.009). Note that because inverse transformation was used, the coefficient of regression for product newness to market (mnewiner) is positive (B=2.487). In Table 1, two indices show the collinearity statistics. First the *tolerance* of a independent variable refers to the proportion of the variable's variance not accounted for by other independent variables in the equation. A variable with very low tolerance contributes little information to a model, and can cause computational problems. In Table 1, the tolerance index of $MNEWIER^3$ is 0.076. The low tolerance value of $MNEWIER^3$ suggests that this variable contributes little information to the model. Another index, Variance Inflation Factor (*VIF*), is defined as the reciprocal of the tolerance. As the VIF increases, so does the variance of the regression coefficient, making it an unstable estimate. From Table 1, it can be seen that the level of multi-collinearity is not very serious, only one VIF value is greater than 10. But there is still room to reduce the multi-collinearity. The method used here is simply to remove variables which did not cause significant changes in the goodness of fit (R^2). The formula testing whether the change was significant was the same as it was described in equation (6.9). The process of eliminate insignificant variables iterated until no variables could be removed without significantly influence R^2 of the model. This method is called as the backward regression method. The remove probability was set as p=0.10. The result of the final statistics is exhibited in Table 2.

Table 2 The impact of product newness on linearity of NPD process

Dependent variable Linearity

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	4.140	.112		36.964	.000		
	CNEWER**2	.167	.078	.162	2.142	.034	.978	1.023
	MNEWINER	1.249	.440	.214	2.837	.005	.978	1.023

R^2=0.082 F(2,167)=7.391 Sig. F=0.001

It can be seen from Table 2 that two items contribute significantly to the linearity of NPD processes:cnewer^2 and mnewiner. Mnewiner, again, showed the significant inverse relationship between market newness of the product and the linearity of NPD process. Cnewer^2, on the other side, showed the quadratic relationship between product newness to company (cnew) and linearity of NPD processes (Beta=0.162, p=0.034). It indicated that both the higher value and lower value of cnew associated with higher linearity of NPD processes. When cnew was near its mean value, that is, cnewer equalled zero, its contribution to linearity of NPD process reached the lowest point. In other words, given the same level of product newness to market, when cnew was near its mean, the NPD process became more non-linear.

2) The interaction items

The further question that raised on the basis of above analysis was that when both the product newness to company (cnew) and the product newness to technology (tnew) were high, would the NPD process still be linear? This question was answered by testing whether the interaction item cnew*tnew had significant effect on linearity of NPD processes. Hierarchical multiple regression techniques (Jaccards, Turris, and Wan 1990) were used here. Two equations were constructed as follows:

Linearity=b0+b1*cnewer+b2*mnewer+b3*tnewer (2)

Linearity=b0+b1*cnewer+b2*mnewer+b3*tnewer+b4*cnewer*tnewer (3)

Where cnewer=cnew-mean of cnew: centered value of product newness to market
tnewer=tnew-mean of tnew: centered value of product newness to technology
mnewer=mnew-mean of mnew: centered value of product newness to market

The OLS estimation of equation (2) is shown in Table 3. The OLS estimation of equation (3) is shown in Table 4.

Table 3 Newness and linearity of NPD process

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	4.305	.090		47.740	.000		
	CNEWER	3.9E-06	.106	.000	.000	1.000	.804	1.244
	MNEWER	-.232	.109	-.168	-2.125	.035	.931	1.074
	TNEWER	-6.6E-02	.107	-.052	-.617	.538	.811	1.233

R^2=0.04 F(3,166)=1.983 Sig. F=0.118

Table 4 The interaction of product newness to company and product newness to technology

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	4.188	.093		45.214	.000		
	CNEWER	7.4E-03	.102	.006	.072	.942	.804	1.244
	MNEWER	-.267	.106	-.193	-2.524	.013	.924	1.082
	TNEWER	-3.5E-02	.103	-.028	-.337	.737	.806	1.241
	CNEWER*TNEWER	.314	.085	.272	3.678	.000	.986	1.015

R^2=0.11 F(4,165)=4.981 Sig. F=0.001

To test the significance of the interaction effect cnewer*tnewer, the testing method described earlier was used. The F index recommended in Jaccard, Turrisi and Wan (1990) measured whether changes of the goodness of fit (R^2) caused by the interaction item was significant. The formula for calculation of F was given in equation (6.9) in section 6.1.3.

Let R_1^2 be the degree of goodness of fit for the main effect equation (2), k_1 be the number of independent variables in the equation. From Table 3, R_1^2 =0.04, k_1 =3.

Let R_2^2 be the degree of goodness of fit for the main effect plus interaction equation (3), k_2 be the number of independent variables of the equation. From Table 4, R_2^2 =0.11, k_2 =4.

By formula (6.9), it was easy to calculate

$$F=\frac{(R_2^2-R_1^2)/(k_2-k_1)}{(1-R_2^2)/(N-k_2-1)}=\frac{(0.11-0.04)/(4-3)}{(1-0.11)/(170-4-1)}=11.12 \qquad (4)$$

The interaction effect was significant at $p<0.001$ level.

It can be seen from Table 4 that the t value of the interaction effect was significant (Beta=0.272, P<0.001). The positive regression coefficient of the interaction item showed that if a product was new to a company, the NPD in that company was most likely to adopt a linear, step by step process. The effect was strengthened while at the same time the product was new to the technology.

3) The influence of other variables

Further to the estimation of the relationship between market newness and linearity of NPD in Table 2, the possible influence of other factors to the linearity of NPD process was considered. These influences were: type of products, industry differences, complexity of products, involvement of company to NPD, type of organisation, and size of the company. Only difference in industry sector showed significant contribution to the model. The result is shown in Table 5.

Table 5 Newness impact on linearity of NPD processes

Dependent variable: Linearity

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.866	.150		25.829	.000		
	CNEWER**2	.181	.077	.175	2.363	.019	.973	1.028
	MNEWINER	1.221	.432	.209	2.823	.005	.977	1.023
	SECTOR2	.467	.173	.198	2.696	.008	.995	1.005

$R^2=0.121$ $F(3,164)=7.536$ Sig. $F=0.0001$

```
Where cnewer=cnew-mean of cnew: centered value of product newness to
      market
      mnewin=1/mnew, the inverse of product newness to market
      mnewiner=mnewin-mean of mnewin: centered value of mnewin
```

$$\text{Sector2}=\begin{cases}1 & \text{Communications technology products manufacturer}\\ 0 & \text{Others}\end{cases}$$

It was noted that communications technology products manufacturers were more likely to adopt a linear process than computer products manufacturers did (Beta=0.198, p=0.008).

B. The interaction effct of the linearity of the NPD processes and product newness to market

Hypothesis H1a was tested via a comparison of two equations as follows:

$$Fperform = a0+a1*liner+a2*mnewer+e \quad (5)$$

$$Fperform = b0+b1*liner+b2*mnewer+b3*liner*mnewer+e \quad (6)$$

Where Fperform: Financial performance of the product

Liner: centered value of the linearity of NPD processes

Mnewer: centered value of product newness to market

In both equation (5) and (6), the dependent variable was financial performance. The difference between (6) and (5) was that in (6) the interaction item between linearity and product newness to market was added.

The estimation of equation (5) yielded table 6.

Table 6 The effect of product newness and linearity of NPD process on financial performance of the product

Model	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	3.447	.062		55.710	.000
LINER	-4.7E-02	.054	-.069	-.869	.386
MNEWER	3.3E-02	.073	.036	.455	.650

$R^2=0.007$ $F(2,162)=0.566$ Sig. $F=0.569$

The estimation of equation (6) yielded Table 7.

Table 7 Testing of the interaction effect on financial performance of the product

Model	Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
(Constant)	3.475	.062		56.270	.000
LINER	-2.1E-02	.054	-.032	-.400	.690
MNEWER	8.0E-03	.073	.009	.110	.913
LINER*MNEWER	.163	.063	.206	2.592	.010

R^2=0.047 F(3,161)=2.63 Sig. F=0.052

The statistical significance of the estimation of equation (6) was p=0.052>0.05, so no further test for the interaction item was done. From Table 7 it can be seen that only the interaction item was significantly related to the financial performance (p=0.01). Further exploration was then done to find a better fit between the interaction item and the financial performance of the product. Because the negative relationship between linearity of NPD processes and product newness to market, the interaction item used was nonlinearity by mnew, where non-linearity is the complementary of the linearity index. Because linearity was measured by a seven point semantic differential, nonlinearity=8-linearity. That is when linearity was 7, the nonlinearity would be 1. While the linearity was 1, the nonlinearity would be 7. As it was described in the overview section 6.1, two non-linear models were tried in finding a better fit between the interaction item, nonlinearity*mnew and financial performance of the product. These two nonlinear models were inverse model and the S-model. The S model yielded a better fit than the inverse model. The result of the regression for financial performance was shown in Fig. 1.

It can be seen from Fig. 1 that about 10% (R^2 =0.09758) of variances of the financial performance can be interpreted by a S-curve of the interaction item between the non-linearity of NPD processes and the market newness of the product. This phenomenon was not a surprise as it confirmed hypothesis H1a that the higher the interaction, the better the performance. It suggested, however, that there was a limit beyond which the increasing of interaction would not improve the financial performance of the product.

Fig. 1 The interaction effect of the product newness to market and linearity of the NPD processes

```
Dependent variable.. FPERFORM          Method.. S

Listwise Deletion of Missing Data

Multiple R           .31238
R Square             .09758
Adjusted R Square    .09204
Standard Error       .26988

            Analysis of Variance:

                DF   Sum of Squares      Mean Square

Regression       1          1.283781        1.2837812
Residuals      163         11.872482         .0728373

F =      17.62532       Signif F =  .0000

-------------------- Variables in the Equation --------------------

Variable                    B         SE B       Beta          T  Sig T

LINMNEW             -.714184     .170114   -.312377     -4.198  .0000
(Constant)          1.315988     .034060                38.637  .0000
```

Where Linmnew=Nonlinearity*mnew

Nonlinearity=8-linearity

The process of testing hypothesis H1a used above was also useful in carrying out in testing hypothesis H1b. Recall that H1b was stated as: other thing being equal, reducing the number of design iterations yields better performance. From the estimation of equation (5) (Table 6), it can be seen that the evidence did not support a significant relationship between the linearity of NPD processes and its financial performance (sig. F=0.832).

Although no conclusions can be derived from the estimation of the equation 6 (Table 7), it can be served as a heuristic illustration. From Table 7, it can be seen that linearity of NPD process was related to financial performance of the product in the following way (Sig. F=0.052):

$$\begin{aligned} \text{Fperformance} &= 3.475-0.021*\text{liner}+0.008*\text{mner}+0.163*\text{liner}*\text{mnewer} \quad (8) \\ &= 3.475+0.008\text{mnewer}+(-0.021+0.163*\text{mnewer})*\text{liner} \end{aligned}$$

The slope of liner (linearity) was -0.021+0.163*mnewer, which was an increasing function of mnewer (product newness to market). The value of the slope was positive, while mnewer was greater than 0.021/0.163=0.129. In other words, to a new to market product (mnewer>0.129), increasing the linearity of NPD process was helpful in improving financial performance of the product. While for a not new to market product (mnewer<0.129), the value of the slope was negative, hence increasing the linearity of NPD processes would do no good in improving the financial performance of the product.

This result, however, revealed that a more complicated relationship between the linearity of NPD processes and financial performance of the product may exist. Therefore further exploration was necessary. Considering the interaction effect between product newness to market and linearity of NPD processes on financial performance may have a non-linear relationship, the following equation was formed

$$\text{FPERFORM}=b0+b1*\text{LINEARIA} +b2* \text{MNEW}+b3*\text{LINMNEWI} \quad (9)$$

Where LINEARIA: Non-linearity, defined as 8-LINEARITY

MNEW: Newness to market of the product

LINMNEWI=1/(NONLINEARITY*MNEW)

The estimation results for equation (9) is shown in Table 8.

Table 8 Newness, Linearity and their interaction on the financial performance of the product

Dependent Variable: FPERFORM

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	5.267	.539		9.779	.000		
	MNEW	-.245	.096	-.264	-2.543	.012	.515	1.940
	LINEARIA	-.170	.072	-.250	-2.352	.020	.492	2.034
	LINMNEWI	-3.909	.885	-.591	-4.416	.000	.309	3.234

R^2=0.10 $F(3,161)$=5.958 Sig. F=0.001

From Table 8, following formula was obtained:

F=5.267-.25M-.17L-3.9/ML (10)

Where L: non-linearity M: market newness of the product F: financial performance of the product

The L by M curve was shown in Fig. 2, given M=1, 2, 3, 4, 5.

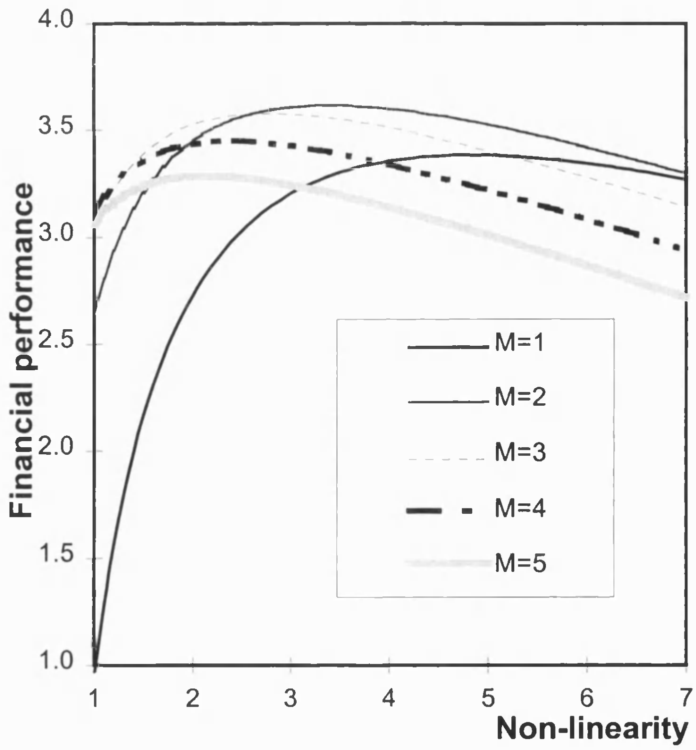

Fig. 6.3 The interaction effect

A simple calculation yields the maximum point for F when M is fixed:

Maximum $L=4.78/\sqrt{M}$ (11)

While M=1, 2, 3, 4, 5 L=4.78, 3.37, 2.75, 2.39, 2.14 correspondingly.

It can be seen that while M was large, reducing the number of design interactions (non-linearity) would yield a better performance. While M was lower, increasing the number of design iterations would yield a better performance.

REFERENCES (See Bibliography)

Appendix IX The Parallel Level and Product Newness: the Data Analysis

The objective of this appendix is to provide a more detailed account for the results presented in Chapter 6, section 6.3.3, in which the test results for hypothesis H2a and H2b were presented.

H2a. The higher the interaction between the parallel level and product newness, the better the performance.

H2b. Other things being equal, increasing the level of overlapping yields a better performance.

Similar to the method used in section 6.2.3 in testing H1a (see also Appendix VIII, part B), two equations were constructed. The product newness variable will be limited to product newness to technology. In the first instance, the dependent variable is financial performance of the product.

$$Fperform=a0+a1*tnewer+a2*paraler \quad (1)$$

$$Fperform=b0+b1*tnewer+b2*paraler+b3*tnewer*paraler \quad (2)$$

Where Fperform: financial performance of the product.

tnewer: centered value of product newness to technology.

paraler: centered value of the parallel level of NPD processes.

The estimation of both (1) and (2) showed that no significant relationships existed. Therefore hypothesis H2a was not directly supported. Considering possible non-linear relationships, an inverse transformation of the interaction item was made. Similar to (1) and (2), two other equation were constructed:

$$Fperform=a0+a1*tnew+a2*parallel \quad (3)$$

$$Fperform=b0+b1*tnew+b2*parallel+b3/(tnew*parallel) \quad (4)$$

Where Fperform: financial performance of the product.

tnew: product newness to technology.

parallel: the paralel level of NPD processes.

The estimation of equation (3) obtained Table 1.

Table 1 The impact on financial performance of the product

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	3.131	.248		12.645	.000		
PARALLEL	3.2E-02	.042	.062	.775	.440	.971	1.030
TNEW	6.7E-02	.069	.078	.975	.331	.971	1.030

R^2=0.01 F(2,160)=.930 Sig. F=0.397

The estimation of equation (4) obtained Table 2.

Table 2 The interaction impact on financial performance of the product

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	4.290	.467		9.194	.000		
TNEW	-.266	.133	-.308	-2.000	.047	.249	4.020
PARALLEL	.334	.112	.640	2.993	.003	.129	7.753
1/(PARALLEL*TNEW)	-.990	.341	-.677	-2.904	.004	.109	9.195

R^2=0.06 F(3,159)=5.461 Sig. F=0.018

Again using the method recommended in Jaccard, Turris and Wan (1990), the changes of the item 1/(parallel*tnew) caused were measured by F index as it was specified in equation (6.9) in section 6.1.3, From Table 1, R_1^2=0.01, k_1=2. From Table 2, R_2^2=0.06, k_2=3.

By formula (6.9), it was easy to calculate

$$F=\frac{(0.061-0.011)/(3-2)}{(1-0.061)/(159-3-1)}=8.253$$

Therefore the interaction between parallel level of NPD processes and product newness to technology can not be ignored (p<0.01). The result in Table 2 can be rewritten as

Fperform=4.290-.266*tnew+.334*parallel-.99/(parallel*tnew) (5)

It can be seen from equation (5) that the interaction between the parallel level of NPD processes and product newness to technology (parallel *tnew) contributed positively to financial performance of the product. Therefore, the higher the interaction between product newness to technology and the parallel level of the product the better the financial performance of the product. Therefore hypothesis H2a was supported. Hypothesis H2b was also supported by equation (5). From equation (5), the contribution of the parallel level of NPD processes to financial performance of the product was divided into two items: .334*parallel, and -.99/(parallel*tnew). Both items were increasing functions of the variable "parallel". Therefore given a fixed value of tnew the higher the parallel level of the NPD processes, the better the financial performance of the product. This supported hypothesis H2b which stated that other things being equal, increasing the level of overlapping yields a better financial performance.

A similar procedure was done while the dependent variable in equation (1) and (2) changed into customer performance of the product, no significant results were obtained.

Appendix X The Formality and Product Newness: the Data Analysis

The objective of this appendix is to provide a more detailed account for the results presented in Chapter 6, section 6.4.2 and section 6.4.3. It is divided into two parts. Part A, further explorations, corresponds to section 6.4.2. Part B, the effect on performance, corresponds to section 6.4.3.

A. Further Explorations

While H3 was not supported by the survey data, it was desirable to explore further whether there exists non-linear relationships between product newness variables and the formality of NPD processes. Another important influence variable for the formality of the NPD process is complexity of the products. The more complicated the product development is, the more likely formal NPD processes will be adopted (Griffin, 1997). Industry practice and types of products may influence the formality of NPD processes as well. To consider all these factors together, a multi-regression procedure specified in the following equations was performed:

$$\begin{aligned}\text{Formality} = {} & b0+b1*cnew+b2*cnew^2+b3*cnew^3+b4*mnew+b5*mnew^2+b6*mnew^3 \\ & +b7*tnew+b8*tnew^2+b9*tnew^3+b10*icomp+b11*ecomp+b12*involve1+b13*involve2 \\ & +b14*involve3+b15*o\_type1+b16*o\_type2+b17*o\_type3+b18*p\_type1+b19*p\_type2 \\ & +b20*p\_type3+b21*saletime+b22*sector1+b23*sector2+b24*size1+b25*size2\end{aligned} \quad (1)$$

Where

cnew: newness to market of the product

mnew:newness to company of the product

tnew:newness to technology of the product

icomp: Internal complexity of the product

ecomp: External complexity of the product saletime: number of years the product has been launched

$$\text{Involve1}=\begin{cases}1 & \text{The company gets involved in the whole procedure of NPD}\\ 0 & \text{Others}\end{cases}$$

$$\text{Involve2}=\begin{cases}1 & \text{We only participate in part of the NPD}\\ 0 & \text{Others}\end{cases}$$

$$\text{Involve3}=\begin{cases}1 & \text{The company does not develop new products, it only responsible for the manufacturing of products}\\ 0 & \text{Others}\end{cases}$$

$$\text{O\_type1}=\begin{cases}1 & \text{Wholly UK owned organization}\\ 0 & \text{Others}\end{cases}$$

$$\text{O\_type2}=\begin{cases}1 & \text{International with UK headquarters}\\ 0 & \text{Others}\end{cases}$$

$$\text{O\_type3}=\begin{cases}1 & \text{UK subsidiary of a multi - national}\\ 0 & \text{Others}\end{cases}$$

$$\text{Sector1}=\begin{cases}1 & \text{Computer products manufacturer}\\ 0 & \text{Others}\end{cases}$$

$$\text{Sector2}=\begin{cases}1 & \text{Communications products manufacturer}\\ 0 & \text{Others}\end{cases}$$

$$\text{P\_type1}=\begin{cases}1 & \text{Communications technology products}\\ 0 & \text{Others}\end{cases}$$

$$\text{P\_type2}=\begin{cases}1 & \text{Computer products}\\ 0 & \text{Others}\end{cases}$$

$$\text{P\_type3}=\begin{cases}1 & \text{Electronic products}\\ 0 & \text{Others}\end{cases}$$

Again, the protective principle described by Cohen and Cohen (1983) was implied. The basic idea was to treat the whole independent variables as a set. If it was significantly related to the formality of NPD processes then further exploration such as backward regression method would be used, otherwise the exploration process would be stopped there. The estimation results of equation (1) are shown in Table 1.

Table 1 Formality and product newness

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	Collinearity Statistics VIF
1	(Constant)	2.971	.832		3.569	.000		
	CNEWER	.215	.117	.278	1.840	.068	.216	4.620
	CNEWER**2	5.1E-02	.064	.079	.792	.429	.500	1.999
	CNEWER**3	-6.6E-02	.045	-.243	-1.482	.140	.184	5.448
	MNEWER	1.4E-02	.116	.016	.118	.906	.268	3.737
	MNEWER**2	-7.1E-02	.082	-.105	-.873	.384	.340	2.940
	MNEWER**3	2.4E-02	.049	.083	.488	.626	.171	5.844
	TNEWER	-1.1E-02	.119	-.015	-.096	.923	.214	4.684
	TNEWER**2	1.2E-02	.055	.020	.214	.831	.568	1.761
	TNEWER**3	-2.9E-02	.041	-.117	-.706	.481	.180	5.565
	ICOMP	8.6E-02	.036	.201	2.383	.018	.694	1.442
	ECOMP	-5.0E-03	.034	-.012	-.149	.882	.748	1.337
	O_TYPE1	.348	.334	.237	1.042	.299	.096	10.456
	O_TYPE2	.231	.352	.117	.657	.512	.156	6.391
	O_TYPE3	.436	.333	.283	1.310	.192	.106	9.432
	INVOLVE1	.123	.707	.059	.173	.863	.043	23.503
	INVOLVE2	-.350	.728	-.146	-.481	.631	.053	18.782
	INVOLVE3	6.8E-02	.780	.017	.088	.930	.129	7.763
	P_TYPE1	.336	.165	.196	2.044	.043	.538	1.859
	P_TYPE2	-3.6E-02	.171	-.021	-.213	.832	.510	1.962
	P_TYPE3	.273	.157	.168	1.740	.084	.533	1.875
	SALETIME	-.157	.049	-.262	-3.204	.002	.742	1.347
	SECTOR1	.183	.154	.109	1.190	.236	.595	1.681
	SECTOR2	4.9E-03	.139	.003	.035	.972	.560	1.786
	SIZE1	.354	.198	.181	1.789	.076	.481	2.080
	SIZE2	.111	.137	.075	.809	.420	.571	1.751

$R^2=0.28$ $F(25,145)=2.209$ Sig. F=0.003

The model explained 28% of the total variance. It can be seen in Table 1, however, multi-collinearity still existed in the model. Therefore further reduction of variables was necessary. Using the backward regression method described in Appendix VIII, insignificant variables were eliminated, the final statistics was shown in Table 2.

Table 2 Newness, complexity and formality

Model	Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	Collinearity Statistics VIF
(Constant)	3.671	.143		25.684	.000		
CNEWER	.220	.094	.284	2.331	.021	.313	3.190
CNEWER**3	-7.7E-02	.034	-.282	-2.257	.025	.299	3.346
TNEWER**3	-3.5E-02	.019	-.141	-1.789	.075	.755	1.325
ICOMP	8.3E-02	.031	.194	2.648	.009	.865	1.156
INVOLVE2	-.443	.168	-.185	-2.635	.009	.942	1.062
P_TYPE1	.287	.128	.167	2.245	.026	.843	1.187
P_TYPE3	.269	.121	.165	2.218	.028	.845	1.184
SALETIME	-.170	.045	-.284	-3.810	.000	.837	1.194
SIZE1	.303	.139	.155	2.185	.030	.926	1.080

R^2=0.25 F(9,161)=5.935 Sig. F=0.000

Table 2 shows that the relationship between product newness and the formality of NPD processes was not linear. The contribution of technological newness of the product to the formality of NPD processes, for example, can be written as $-.033*\text{tnewer}^3$. It showed that other things being equal, the higher tnewer (product newness to technology), the more informal NPD process would be. The contribution of product newness to company to the formality of NPD processes was

$$S=0.22*\text{cnewer}-0.077\text{cnewer}^3 \qquad (2)$$

S was not a monotonic function of cnewer. While cnewer reached its maximum point (say a completely new product), S was in its minimum, that is the least informal point. While cnewer reached its minimum point (say a not new to company product), S was in its maximum, that is a very formal process. Therefore the exploration showed that at the extreme point of product newness to company, higher product newness to company corresponding to an informal NPD process, lower product newness to company corresponding to a formal NPD process. The relationship of product newness to company and the formality of the NPD process, however, was a cubic relationship instead of a linear one.

As for other factors, the influence of product complexity on the formality of NPD processes was as expected. If the product was internally complicated, that means more people were involved in the development, then more controls were enforced and more organisation work took place, therefore more formal the process would be. In Table 2, the internal complexity showed a positive contribution to the formality of NPD processes (Beta=0.194, p=0.009<0.01).

Understandably, large companies (SIZE1) adopted a more formal process than small and medium sized companies (Beta=0.155, p=0.03). Types of products developed also pay contribution to the formality of NPD processes. Communications products (P_TYPE1) and electronics products (P_TYPE3) adopted more formal NPD processes than computer products (Beta=0.167 p=0.026 for communications technology products and Beta=0.165 p=0.028 for electronics products).

Finally, there was a trend in this industry sector that, the NPD process was going to be more and more formal (Beta=-.284, p=0.000).

B. The Effect on Performance

Part B relates to section 6.4.3, which examines hypothesis H3a and H3b.

H3a. The higher the interaction between product newness and the formality of NPD processes, the better the product performance.

H3b. Other things being equal, increasing the formality of NPD processes yields better performance.

Without the guide from the test results of H3, two equations were constructed as follows:

Fperform=a0+a1*cnewer+a2*mnewer+a3*tnewer+a4*former (3)

Fperform=b0+b1*cnewer+b2*mnewer+b3*tnewer+b4*former+b5cnewer*former +b6*mnewer*former+b7*tnewer*former (4)

Equation (4) has three more interaction items than in equation (3). These three interaction items are interactions of the formality of NPD processes with each of the three product newness variables respectively. The estimation results of equation (3) and equation (4) showed that the three interaction items did not played a significant role in explaining financial performance of the product. Therefore hypothesis H3a was not supported. Because of the insignificance of equation (3), the hypothesis H3b was also not supported.

Further explorations

Considering the possible non-linear relationship between product newness and product performance, a polynomial equation was done via following equation:

$$\begin{aligned} fperform= {} & b0+b1*cnewer+b2*cnewer^2+b3*cnewer^3+b4*tnewer+b5*tnewer^2+b6*tnewer^3 \quad (5) \\ & +b7*mnewer+b8*mnewer^2+b9*mnewer^3+b10*former+b11*former*cnewer \\ & +b12*former* cnewer^2+b13*former* cnewer^3+b14*former*tnewer \\ & +b15*former* tnewer^2+b16*former* tnewer^3+b17*former*mnewer \\ & +b18*former* mnewer^2+b19*former* mnewer^3 \end{aligned}$$

Where cnewer=cnew-mean of cnew: centered value of product newness to market

tnewer=tnew-mean of tnew: centered value of product newness to technology

mnewer=mnew-mean of mnew: centered value of product newness to market

former=formality-mean of formality: centered value of the formality scale of NPD process

The initial regression results for equation (5) is shown in Table 3.

Table 3 The interaction effect of newness and formality on the financial performance of new product

	Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
	B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1 (Constant)	3.581	.104		34.440	.000		
CNEWER	-7.942E-02	.137	-.095	-.578	.564	.217	4.616
CNEWER2	-1.391E-02	.073	-.019	-.191	.849	.591	1.692
CNEWER3	6.519E-03	.059	.021	.110	.912	.167	5.995
MNEWER	.165	.132	.179	1.245	.215	.282	3.552
MNEWER2	-4.937E-02	.093	-.068	-.532	.595	.357	2.801
MNEWER3	-4.317E-02	.059	-.142	-.727	.469	.154	6.485
TNEWER	-1.870E-02	.131	-.022	-.142	.887	.249	4.015
TNEWER2	-5.303E-02	.065	-.081	-.818	.415	.599	1.671
TNEWER3	2.092E-02	.047	.075	.447	.655	.207	4.828
FORMER*CNEWER	-8.455E-02	.187	-.077	-.452	.652	.202	4.952
FORMER*CNEWER2	.118	.094	.163	1.253	.212	.344	2.908
FORMER*CNEWER3	.135	.077	.348	1.755	.081	.148	6.741
FORMER*MNEWER	-.233	.206	-.186	-1.131	.260	.216	4.626
FORMER*MNEWER2	-6.027E-03	.114	-.008	-.053	.958	.278	3.595
FORMER*MNEWER3	.125	.083	.327	1.516	.132	.125	7.971
FORMER*TNEWER	.146	.178	.146	.819	.414	.184	5.432
FORMER*TNEWER2	-.196	.079	-.334	-2.473	.015	.321	3.113
FORMER*TNEWER3	-8.056E-02	.058	-.273	-1.390	.167	.152	6.589

R^2=0.14 F(18, 147)=1.132 Sig. F=0.176

The final results of backward regression for equation (5) is shown in table 4.

Table 4 The interaction effect of formality and newness on financial performance of the product

	Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
Model	B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1 (Constant)	3.462	.060		57.860	.000		
FORMER*CNEWER2	.126	.073	.175	1.733	.085	.560	1.787
FORMER*CNEWER3	7.572E-02	.030	.195	2.535	.012	.959	1.043
FORMER*TNEWER2	-.145	.059	-.247	-2.456	.015	.563	1.775

R^2=0.08 F(18,147)=4.481 Sig. F=0.005

Again the significance of the three interaction items as a whole was tested according to the equation (6.9) in section 6.1.3.

Let R_1^2 be the degree of goodness of fit for the main effect equation, in this case the equation was

$$\text{fperform} = b0+b1*\text{cnewer}^2+b2*\text{cnewer}^3+b3*\text{tnewer}^2+b4*\text{former} \qquad (6)$$

k_1 be the number of independent variables in the main effect equation

Let R_2^2 be the degree of goodness of fit for the main effect plus interaction equation, in this case the equation was

$$\text{fperform} = b0+b1*\text{cnewer}^2+b2*\text{cnewer}^3+b3*\text{tnewer}^2+b4*\text{former} \qquad (7)$$
$$+b5*\text{former}*\text{cnewer}^2+b6*\text{former}*\text{cnewer}^3+b7*\text{former}*\text{tnewer}^2$$

k_2 be the number of independent variables for the main effect plus interaction equation.

Applying OLS on equation (6) and (7) using the survey data, it was obtained

R_1^2 =0.037, R_2^2 =0.108, k_1=4, k_2=7

By equation (6.9), it was easy to calculate

$$F=\frac{(0.108-0.037)/(7-4)}{(1-.108)/(165-7-1)}=4.1655$$

That confirmed the interaction effect was significant at 0.05 level. Therefore the results obtained in Table 4 can be used to analyse further why H3a and H3b was not supported.

From Table 4, the following formula was obtained,

Contribution of the interaction effect on financial performance of the product:

$$\text{fperform}=3.462+0.126\text{former}*\text{cnewer}^2+0.076*\text{former}*\text{cnewer}^3-0.145*\text{former}*\text{tnewer}^2 \qquad (8)$$

It can be seen from equation (8) that the formality of NPD processes can contribute negatively or positively to the financial performance of the product:

1. The contribution of the formality to financial performance of the product regarding product newness to company is explained by the second item and the third item in equation (8). That is:

$$(0.126+0.076*\text{cnewer})*\text{cnewer}^2*\text{former} \qquad (9)$$

To put it further, the interaction curve

$$S=(0.126+0.076*cnewer)*cnewer^2 \quad (10)$$

was drawn in Fig. 1.

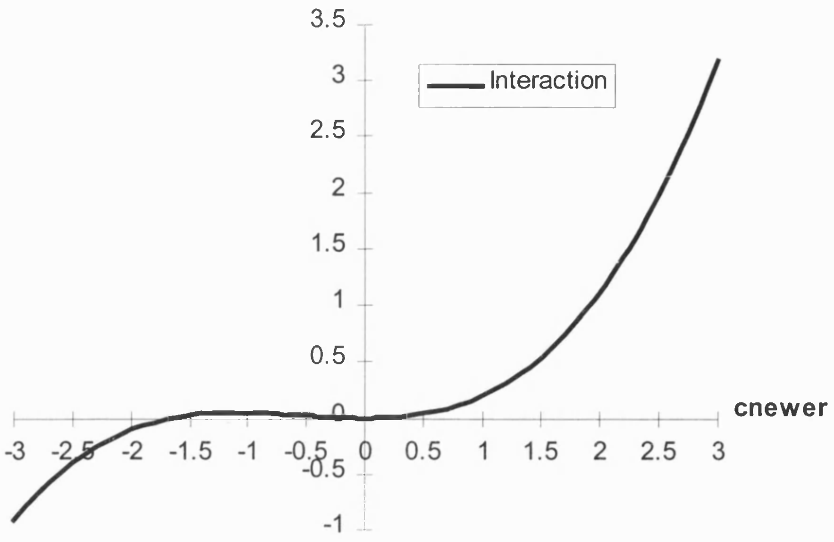

Fig. 1 The interaction effect of formality and product newness to company

Recall that cnewer is the centered value of product newness to company, cnew (Mean of cnew=3.45, Standard deviation of cnew=0.95, 5 point Likert scale), the value of S is largely positive (within 95% confidential level of cnewer). The contribution of the formality regarding product newness to company was hence positive. The effect was stronger when the product newness to company was higher.

2. The contribution of the formality to financial performance of the product regarding product newness to technology was interpreted by the last item in equation (8). That is

$$-0.145*tnewer^2*former \quad (11)$$

So the contribution of the formality regarding product newness to technology was negative. Recall that tnewer is the centered value of product newness to technology, tnew (mean of tnew=3.30, standard deviation=0.93, 5 point Likert scale), then the farther tnew is apart from its mean value, the higher the absolute value of tnewer, thus the larger the value of $tnewer^2$, hence the stronger the negative effect of formality to financial performance of the product.

Similarly while the performance variable was changed into customer performance, the above procedure was repeated. The results showed no significant influence of the three interaction items.

In summary, there was no evidence to show that there existed a linear relationship between product newness and the formality of NPD processes. Nor was there evidence to show that the formality or the interaction between the formality and product newness related positively or negatively to the performance of the product.

Further explorations, however revealed that a more complicated relationship between product newness and the formality of NPD processes existed. It was found that product newness to company and product newness to technology had a cubic relationship to the formality of NPD processes. It was also found that the role of the formality on product performance was double edged. On the one hand, for highly new to company product, it has positive contributions. On the other hand, for highly new to technology product, highly formal NPD processes would have strong negative effect on the financial performance of the product.

The results also showed that product complexity was perhaps a more important variable which has direct influence on the formality of NPD processes than that of product newness. It was also noted that large company adopted a more formal NPD process than small or medium sized companies. Types of products also contributed to the differences in the formality of NPD processes.

REFERENCES (See Bibliography)

Appendix XI The Role Flexibility of Marketing and Product Newness: the Data Analysis

The objective of this appendix is to provide a more detailed account for the results presented in Chapter 6, section 6.5.2, where the exploration results for the relationship between product newness variables and the role flexibility of marketing were presented. As the method of exploration has been explained in previous sections (Section 6.1.3 and Appendix VIII, for example), only the data analysis procedure and the final statistics will be presented in this appendix.

The exploration was divided into two stages 1) joint influence of product newness variables on the role flexibility of marketing without considering control variables 2) Joint influence of product newness variables on the role flexibility of marketing adding control variables.

First the influence of these three perspectives of product newness to the role of marketing in NPD process was explored using following equation

$$Mrole=b0+b1*cnewer+b2*cnewer^3+b3*cnewer^3+b4*tnewer+b5*tnewer^2+b6*tnewer^3 \quad (1)$$

$$+b7*mnewer+b8*mnewer^2+b9*mnewer^3$$

```
Where cnewer=cnew-mean of cnew: centered value of product newness to
      market
      tnewer=tnew-mean of tnew: centered value of product newness to
      technology
      mnewer=mnew-mean of mnew: centered value of product newness to
      market
```

The final statistics for backward regression method was shown in Table 1.

Table 1 The impact of newness on marketing's role

Dependent variable: mrole

Model	Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
	B	Std. Error	Beta	t	Sig.	Tolerance	VIF
(Constant)	2.972	.071		42.027	.000		
MNEWER	.283	.083	.255	3.422	.001	.984	1.016
TNEWER**3	-5.0E-02	.024	-.155	-2.079	.039	.984	1.016

R^2=0.08 F(2,168)=7.238 Sig. F=0.001

It can be seen from Table 1 that two items remained in the final equation: mnewer and tnewer^3. Mnewer, again, showed the significant positive relationship between product newness to market and the marketing's role in NPD processes (Beta=0.255, p=0.001). Tnewer^3 , on the other side, showed the negative relationship between product newness to technology and the marketing's role in NPD processes (Beta=-.155, p=0.039). This supported hypothesis H4b. The newer a product was to technology, the less flexible role marketing played in the process. Or, in other words, given the same level of product newness to market, the newer a product was to technology, the less technical tasks marketing personnel took in the NPD process. This result complemented the observation of Workman (1993) of the weakness of marketing personnel in the context of technology product development.

Secondly, the role marketing played in NPD process might be influenced by other variables such as the size of the company, types of products developed, industry difference, etc. To consider the influence of these control variables with product newness together, multiple regression expressed in equation (2) was used.

$$\text{Role of marketing} = b0+b1*cnewer+b2*cnewer^2+b3*cnewer^3+b4*tnewer+b5*tnewer^2 \quad (2)$$

$$+b6*tnewer^3+b7*mnewer+b8*mnewer^2+b9*mnewer^3$$

$$+b10*icomp+b11*ecomp+b12*involve1+b13*involve2$$

$$+b14*involve3+b15*o\_type1+b16*o\_type2+b17*o\_type3$$

$$+b18*p\_type1+b19*p\_type2+b20*p\_type3+b21*saletime$$

$$+b22*sector1+b23*sector2+b24*size1+b25*size2$$

Where: cnewer=cnew-mean of cnew: centered value of product newness to market

tnewer=tnew-mean of tnew: centered value of product newness to technology

mnewer=mnew-mean of mnew: centered value of product newness to market

icomp: Internal complexity of the product

ecomp: External complexity of the product

saletime: number of years the product has been launched

$$\text{Involve1}=\begin{cases}1 & \text{The company gets involved in the whole procedure of NPD}\\ 0 & \text{Others}\end{cases}$$

$$\text{Involve2}=\begin{cases}1 & \text{We only participate in part of the NPD}\\ 0 & \text{Others}\end{cases}$$

$$\text{Involve3}=\begin{cases}1 & \text{The company does not develop new products, it only responsible for the manufacturing of products}\\ 0 & \text{Others}\end{cases}$$

$$\text{O\_type1}=\begin{cases}1 & \text{Wholly UK owned organization}\\ 0 & \text{Others}\end{cases}$$

$$\text{O\_type2}=\begin{cases}1 & \text{International with UK headquarters}\\ 0 & \text{Others}\end{cases}$$

$$\text{O\_type3}=\begin{cases}1 & \text{UK subsidiary of a multi - national}\\ 0 & \text{Others}\end{cases}$$

$$\text{Sector1}=\begin{cases}1 & \text{Computer products manufacturer}\\ 0 & \text{Others}\end{cases}$$

$$\text{Sector2}=\begin{cases}1 & \text{Communications products manufacturer}\\ 0 & \text{Others}\end{cases}$$

$$\text{P\_type1}=\begin{cases}1 \text{ Communications technology products}\\0 \text{ Others}\end{cases}$$

$$\text{P\_type2}=\begin{cases}1 \text{ Computer products}\\0 \text{ Others}\end{cases}$$

$$\text{P\_type3}=\begin{cases}1 \text{ Electronic products}\\0 \text{ Others}\end{cases}$$

Using backward regression as described in Appendix VIII on equation (2), six independent variables remained in the final regression equation. The regression result is shown in Table 2.

Table 2 Newness and the role of marketing

Model	Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
	B	Std. Error	Beta	t	Sig.	Tolerance	VIF
(Constant)	3.027	.273		11.082	.000		
MNEWER	.274	.082	.248	3.356	.001	.919	1.088
TNEWER**3	-6.5E-02	.023	-.203	-2.806	.006	.962	1.040
ICOMP	.149	.052	.215	2.879	.005	.898	1.114
P_TYPE1	-.321	.169	-.144	-1.897	.060	.866	1.155
SECTOR1	-.388	.167	-.177	-2.322	.021	.860	1.163
SALETIME	-.158	.058	-.204	-2.741	.007	.910	1.098

R^2=0.18 F(6,164)=5.866 Sig. F=0.000

In addition to the influence of product newness variables, the product complexity contributed positively to the role of marketing (Beta=0.215, p=0.005). It showed that the more complex the internal development of a product was, the more flexible role marketing played. The negative contribution of sale time to the role flexibility of marketing (Beta=-.204, p=0.007) showed a trend in the ICT sector that the role flexibility of marketing becomes more and more important. It is also noted that, type 1 products (communications technology products) contributed negatively to the role of marketing (Beta=-.144, p=0.06). Industry sector 1 (computer products manufacturer) also contributed negatively to the role of marketing (Beta=-.177, p=0.021).

REFERENCES (See Bibliography)

Appendix XII The Role Flexibility of R&D and Product Newness: the Data Analysis

The objective of this appendix is to provide a more detailed account for the results presented in Chapter 6, section 6.5.2, where the exploration results for the relationship between product newness variables and the role flexibility of marketing were presented. As the method of exploration has been explained in previous sections (Section 6.1.3 and Appendix VIII, for example), only the data analysis procedure and the final statistics will be presented in this appendix.

Joint influence of product newness variables without considering control variables

The joint influence of the three perspectives of product newness to the role of R&D in NPD process was explored using following equation:

$$rrole= b0+b1*cnewer+b2*cnewer^2+b3*cnewer^3+b4*tnewer+b5*tnewer^2+b6*tnewer^3 \quad (1)$$

$$+b7*mnewer+b8*mnewer^2+b9*mnewer^3$$

```
Where cnewer=cnew-mean of cnew: centered value of product newness to
      market
      tnewer=tnew-mean of tnew: centered value of product newness to
      technology
      mnewer=mnew-mean of mnew: centered value of product newness to
      market
```

This equation considered all the perspectives of product newness as well as their higher order items. To overcome potential collinearity problems the higher order items may bring about, centered value of these variables were used. Backward regression was used with remove probability P=0.10. The results of final statistics were shown in Table 1.

Table 1 The impact of product newness on R&D's role in NPD processes

Dependent variable: rrole

	Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
	B	Std. Error	Beta	t	Sig.	Tolerance	VIF
(Constant)	2.952	.069		42.629	.000		
CNEWER**3	-.100	.028	-.289	-3.536	.001	.807	1.239
MNEWER**3	6.4E-02	.027	.175	2.383	.018	.997	1.003
TNEWER**3	4.9E-02	.026	.155	1.901	.059	.807	1.238

R^2=0.10 F(3,167)=6.254 Sig. F=0.0001

It can be seen from Table 1 that three items remained in the final equation: mnewer^3, tnewer^3, and cnewer^3.

Cnewer^3, again, showed the significant negative relationship between product newness to company and the role flexibility of R&D in NPD processes (Beta=-.289, p=0.001).

Tnewer^3 and mnewer^3, on the other side, showed the positive relationships between product newness to technology, product newness to market and the role flexibility of R&D in NPD processes(Beta=.175, .155, p=0.018, and 0.059) respectively. This partly supported hypothesis H5b. Given level of product newness to market and the level product newness to company unchanged, the newer the product is to technology, the more flexible role R&D played. The result also indicated that given the level of product newness to the company unchanged, the newer the product is to the market, the more flexible role of R&D in the NPD process will play.

Joint influence of product newness variables considering control variables

To consider the influence of control variables on the R&D's role in the NPD process, the multiple regression analysis as expressed in following equation was used:

$$\text{R\&D's role} = b0+b1*cnewer+b2*cnewer^2+b3*cnewer^3+b4*tnewer+b5*tnewer^2 \quad (2)$$

$$+b6*tnewer^3+b7*mnewer+b8*mnewer^2+b9*mnewer^3$$

$$+b10*icomp+b11*ecomp+b12*involve1+b13*involve2$$

$$+b14*involve3+b15*o\_type1+b16*o\_type2+b17*o\_type3$$

$$+b18*p\_type1+b19*p\_type2+b20*p\_type3+b21*saletime$$

$$+b22*sector1+b23*sector2+b24*size1+b25*size2$$

Where: cnewer=cnew-mean of cnew: centered value of product newness to market

tnewer=tnew-mean of tnew: centered value of product newness to technology

mnewer=mnew-mean of mnew: centered value of product newness to market

icomp: Internal complexity of the product

ecomp: External complexity of the product

saletime: number of years the product has been launched

$$\text{Involve1}=\begin{cases}1 \text{ The company gets involved in the whole procedure of NPD}\\0 \text{ Others}\end{cases}$$

$$\text{Involve2}=\begin{cases}1 \text{ We only participate in part of the NPD}\\0 \text{ Others}\end{cases}$$

$$\text{Involve3}=\begin{cases}1 \text{ The company does not develop new products, it only responsible for the manufacturing of products}\\0 \text{ Others}\end{cases}$$

$$\text{O\_type1}=\begin{cases}1 \text{ Wholly UK owned organization}\\0 \text{ Others}\end{cases}$$

$$\text{O\_type2}=\begin{cases}1 \text{ International with UK headquarters}\\0 \text{ Others}\end{cases}$$

$$\text{O\_type3}=\begin{cases}1 \text{ UK subsidiary of a multi - national}\\0 \text{ Others}\end{cases}$$

$$\text{Sector1}=\begin{cases}1 \text{ Computer products manufacturer}\\0 \text{ Others}\end{cases}$$

$$\text{Sector2}=\begin{cases}1 \text{ Communications products manufacturer}\\0 \text{ Others}\end{cases}$$

$$\text{P\_type1}=\begin{cases}1 \text{ Communications technology products}\\0 \text{ Others}\end{cases}$$

$$\text{P\_type2}=\begin{cases}1 \text{ Computer products}\\0 \text{ Others}\end{cases}$$

$$\text{P\_type3}=\begin{cases}1 \text{ Electronic products}\\0 \text{ Others}\end{cases}$$

The regression results were shown in Table 2.

In addition to the influence of the product newness variables to R&D's role in NPD process, the development of communications technology products witnessed less flexible role of R&D than in the development of the other types of products (computer products, and electronics). Two types of organizations stressed the flexible role of R&D in NPD process. That was wholly UK owned organisations(O_TYPE1, Beta=0.535, P=0.013) and UK subsidiary of a multi-national (O_TYPE3, Beta=0.516, P=0.013).

Table 2 Newness to market of the product and R&D's role in NPD process

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	1.962	.393		4.994	.000		
	CNEWER3	-.104	.028	-.300	-3.695	.000	.752	1.329
	MNEWER3	5.453E-02	.026	.150	2.109	.036	.983	1.018
	TNEWER3	5.618E-02	.025	.179	2.243	.026	.778	1.286
	P_TYPE1	-.413	.159	-.190	-2.608	.010	.938	1.066
	SALETIME	9.445E-02	.057	.124	1.668	.097	.896	1.116
	O_TYPE1	.999	.399	.535	2.505	.013	.109	9.192
	O_TYPE2	.758	.419	.302	1.808	.072	.179	5.597
	O_TYPE3	1.010	.403	.516	2.507	.013	.117	8.546

R^2=0.20 F(8,162)=4.916 Sig. F=0.000